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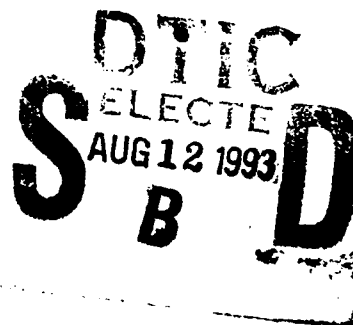


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EVALUATION OF MAIL TRAYS

HQ AFMC/LGTP  
AIR FORCE PACKAGING EVALUATION ACTIVITY  
5215 THURLOW ST  
WRIGHT-PATTERSON AFB, OH 45433-5540  
JUNE 1993

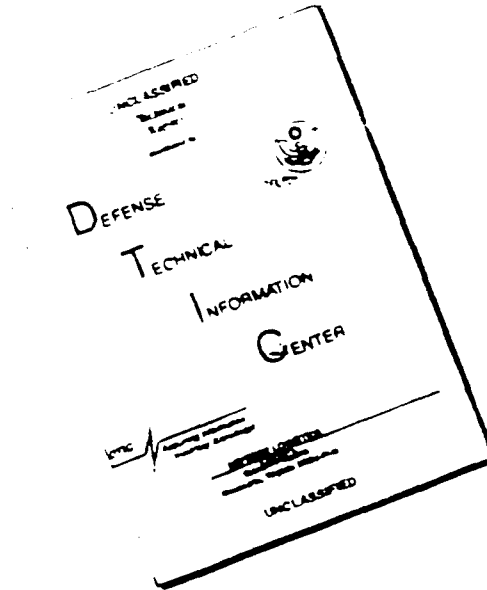
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PROJECT # 92-119

TITLE: Evaluation of Mail Trays

## ABSTRACT

The Air Force Packaging Evaluation Activity (AFPEA), in response to a request from the United States Postal Service Engineering and Development Center (USPS EDC), conducted container testing and materials testing on mail trays and their plastic corrugated material from three manufacturers. The trays were tested against FED-STD-101, Methods 5007.1 and 5019.1 and FED-STD-648A, Paragraph 5.8.3. The material was tested against MIL-P-83668A and MIL-STD-810E, Method 507.3. The mail trays were provided by the USPS EDC. The mail tray material was provided by the manufacturers.

The test series was performed at the Air Force Packaging Evaluation Activity, 5215 Thurlow St, Wright-Patterson AFB, Ohio, 45433-5540.

## SUMMARY

An evaluation was done on the performance of the mail trays and their material.

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## **INTRODUCTION**

The United States Postal Service Engineering and Development Center (USPS EDC) requested testing of Standard Type Mail Trays. Testing included container rough-handling tests and materials testing of the mail tray plastic-corrugated material.

The mail trays were supplied by the USPS and the mail tray material was supplied by three manufacturers, identified as Company A, Company B, and Company C, of the mail trays.

The performance of each of the manufacturers' trays and their materials were evaluated. In total, there were four different trays submitted for testing. Company A had two types of containers which will be referred to as "Co A, Container 1" and "Co A, Container 2". Company B had one type of container which will be referred to as "Co B Container". Company C had one type of container which will be referred to as "Co C Container".

## **CONTAINER AND MATERIAL DESCRIPTION**

The United States Postal Service Standard Type Mail Tray is a small, plastic, laminated corrugated container (Figure 1). The container includes a cover, but the significance of the cover is not part of this test report. (Figure 2). Maximum outer container dimensions are 18.30 inches long, 13.31 inches wide, and 11.43 inches deep.

Co A, Container 1 material is a three-layered, corrugated plastic board, where the layers are laminated by glue. Co A, Container 2 material is a five-layered, corrugated plastic board, where the layers are laminated by a fusion bonding process. Co B Container and Co C Container materials are three-layered, corrugated plastic board, where the layers are laminated by heat fusion.

For purposes of this report, Company A material will be denoted as "Co A, Material 1" and "Co A, Material 2". Company B material will be denoted as "Co B Material" and Company C material will be denoted as "Co C Material".

## **TEST PROCEDURE**

The USPS mail trays and their materials were tested in accordance with the Air Force Packaging Evaluation Activity (AFPEA) Test Plan, Project Number 92-119, dated 5 Oct 92. The test plan referenced FED-STD-101C, FED-STD-648B, MIL-P-83668A, and MIL-STD-810E.

The test methods constitute both the procedures for performing the

tests and performance criteria for evaluation of container and container material acceptability. The tests were performed at AFPEA, 5215 Thurlow St, Wright-Patterson AFB, OH 45433-5540.

Test Sequences 2 through 4 of the mail tray container test plan were performed on all four containers with their lids in place. Test Sequence 5 was performed on all four containers without their lids.

Test Sequences 2 and 3 were performed using the same containers. Test Sequences 4 and 5 were performed using the same containers; but, a different set than those used for test sequences 2 and 3.

The containers were inspected for interior and exterior damage after each test sequence. Inspection included container surfaces and structures, and contents (if applicable).

NOTE: The mail tray test plan rough-handling tests are intended to test containers to failure. It is unlikely that most mail trays would receive handling as rough as this in their normal use.

Test Sequences 2 through 7, of the mail tray material test plan, were performed on material sent by the manufacturers; however, because the glued trays were no longer being manufactured, their material samples were cut from existing glued mail tray containers.

The mail tray material was inspected for cracks, delamination, warping, and any visible damage.

Unless otherwise noted, all specimens had been conditioned at 73°F  $\pm$  5°F and at 50% relative humidity (RH)  $\pm$  5% RH for a minimum of 24 hours prior to and during testing.

The actual sequence of testing is presented in Appendix A.

## **CONTAINER IDENTIFICATION**

The bottom of each container was labeled with the name of the container's manufacturer. Co A, Container 1 was further identified with "glued" labeled on the bottom and Co A, Container 2 was further labeled with "fusion-bonded" on the bottom. The correlation between labeled and designated container faces is as follows:

Labeled Face	Designated Face
1-2	Left End (Left Face 3-4)
3-4	Front Face (U.S. MAIL)
5-6	Right End (Right of Face 3-4)
7-8	Rear Face (PROPERTY OF U.S. POSTAL SERVICE)
BOTTOM	Bottom
TOP	Top

The correlation between labeled and designated container corners is as follows:

Labeled Corner	Designated Corner
8T-1T	Top Corner Between Faces 7-8 & 1-2
2T-3T	Top Corner Between Faces 1-2 & 3-4
4T-5T	Top Corner Between Faces 3-4 & 5-6
6T-7T	Top Corner Between Faces 5-6 & 7-8
8B-1B	Bottom Corner Between Faces 7-8 & 1-2
2B-3B	Bottom Corner Between Faces 1-2 & 3-4
4B-5B	Bottom Corner Between Faces 3-4 & 5-6
6B-7B	Bottom Corner Between Faces 5-6 & 7-8

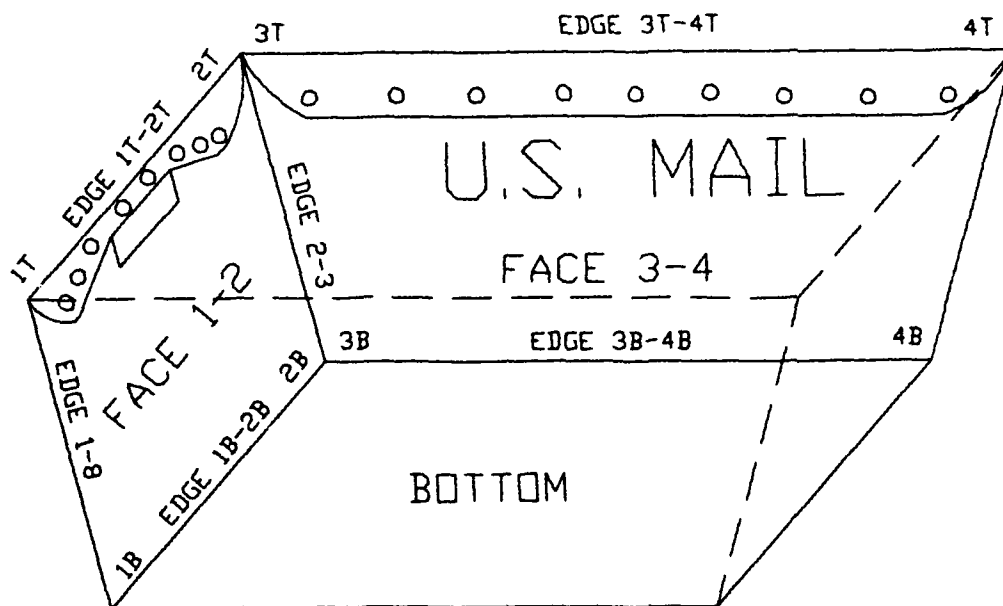
The correlation between labeled and designated container edges is as follows:

Labeled Edge	Designated Edge
1T-2T	Top Edge Between Corners 1T & 2T
3T-4T	Top Edge Between Corners 3T & 4T
5T-6T	Top Edge Between Corners 5T & 6T
7T-8T	Top Edge Between Corners 7T & 8T
1B-2B	Bottom Edge Between Corners 1B & 2B
3B-4B	Bottom Edge Between Corners 3B & 4B
5B-6B	Bottom Edge Between Corners 5B & 6B
7B-8B	Bottom Edge Between Corners 7B & 8B
1-8	Edge Between Faces 7-8 & 1-2
2-3	Edge Between Faces 1-2 & 3-4
4-5	Edge Between Faces 3-4 & 5-6
6-7	Edge Between Faces 5-6 & 7-8

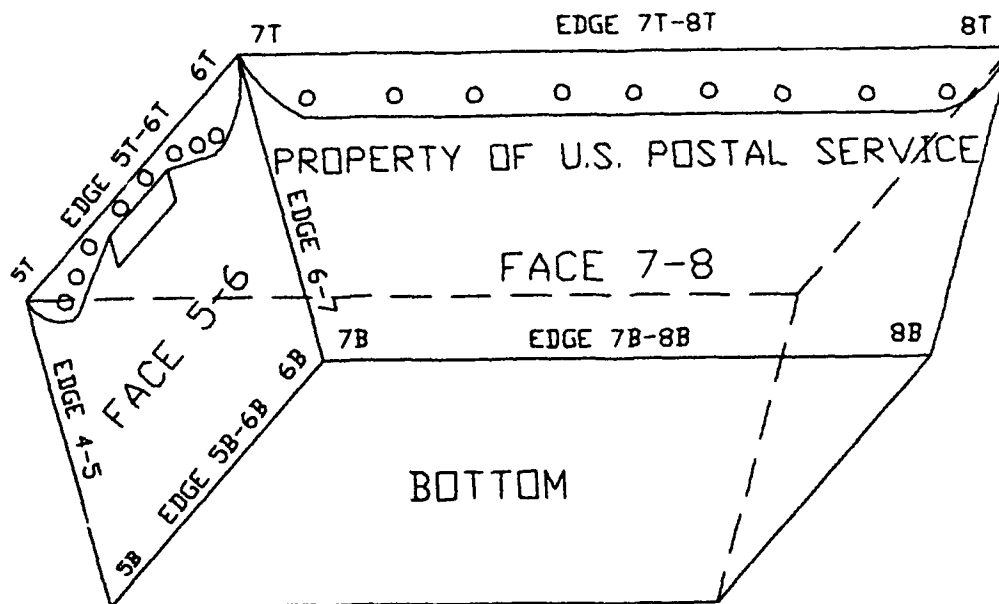
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Sketches 1 and 2 identify the labelled sides, corners and edges as follows:



Sketch 1. Labeled faces, corners and edges on Faces 1-2 and 3-4.



Sketch 2. Labeled faces, corners and edges on Faces 5-6 and 7-8.

## TEST SEQUENCES (MAIL TRAY CONTAINERS)

### TEST SEQUENCE 1 - Measurement and Weight.

A visual inspection of the container was made. The container was equipped with one handle on each end of the container. The handles were cut from each end of the container such that a flap of the cut material was folded onto the rest of the material to form grips.

Container workmanship was visually examined. The container was free of defects that would affect strength, durability, safety or serviceability. Container ultrasonically-fused welds appeared uniform and the container was smooth and free of sharp or jagged edges.

Container color was examined and noted.

The container was not a uniform rectangle in that the top of the container had a larger area than the bottom. Interior and exterior length and width measurements were taken from the top, middle, and bottom of the container. Exterior and interior height measurements were taken.

The following equipment was utilized:

<u>Equipment</u>	<u>Manufacturer</u>	<u>Ser#</u>
Digital Caliper	Mitutoyo	7001683

Three containers from each company were used for taking measurements. A total of five measurements was taken for each dimension. The averages were calculated for each container, and then a grand average was calculated for the length, width, and height for each company.

Abbreviations for the length, width, and height are as follows:

ETL	Exterior-Top-Length	ITL	Interior-Top-Length
ETW	Exterior-Top-Width	ITW	Interior-Top-Width
EML	Exterior-Middle-Length	IML	Interior-Middle-Length
EMW	Exterior-Middle-Width	IMW	Interior-Middle-Width
EBL	Exterior-Bottom-Length	IBL	Interior-Bottom-Length
EBW	Exterior-Bottom-Width	IBW	Interior-Bottom-Width
EH	Exterior-Vertical-Height	IH	Interior-Vertical-Height

The average length, width, and height, in inches, for the four containers are as follows:

<u>Manufacturer</u>	<u>ETL</u>	<u>ETW</u>	<u>EML</u>	<u>EMW</u>	<u>EBL</u>	<u>EBW</u>	<u>EH</u>
Co A, Container 1	18.16	13.11	16.43	11.85	15.09	11.13	11.34
Co A, Container 2	18.18	13.11	16.52	11.94	15.15	11.11	11.43
Co B Container	18.15	13.13	16.64	11.90	15.18	11.20	11.35
Co C Container	18.30	13.31	16.64	12.04	15.27	10.93	11.37

<u>Manufacturer</u>	<u>ITL</u>	<u>ITW</u>	<u>IML</u>	<u>IMW</u>	<u>IBL</u>	<u>IBW</u>	<u>IH</u>
Co A, Container 1	16.98	12.15	15.84	11.63	14.85	10.95	11.21
Co A, Container 2	17.02	12.26	15.80	11.78	14.71	10.80	11.30
Co B Container	16.96	12.19	15.85	11.81	14.88	10.91	11.21
Co C Container	17.12	12.26	15.78	11.83	14.72	10.50	11.22

The weight of each manufacturer's container was determined by taking the weight of three containers, from each manufacturer, and averaging them.

The following equipment was utilized:

<u>Equipment</u>	<u>Manufacturer</u>	<u>Mod#</u>	<u>Cal Exp</u>
Beam Balance	OHAUS	1119	22 Nov 93

The weights of the containers are as follows:

<u>Manufacturer</u>	<u>Weight</u>
Co A, Container 1	805.75 gm
Co A, Container 2	898.33 gm
Co B Container	857.67 gm
Co C Container	829.00 gm

**TEST SEQUENCES 2 & 3** - FED-STD-101C, Method 5007.1, 6.3,  
Procedure A, Free Fall Drop Test.

<u>Equipment</u>	<u>Manufacturer</u>	<u>Model</u>	<u>Ser#</u>	<u>Cal Exp</u>
High Altitude Chamber Drop Tester	Tenney Eng L.A.B.	AD-160	1064018	N/A

The free fall drop tests were conducted in accordance with FED-STD-101C, Method 5007.1. The containers were conditioned at +140°F (test sequence 2) and -20°F (test sequence 3) for 24 hours and then transported to the Conditioning Laboratory where they were loaded with a test load of 30 lb. of white bond paper (Figure 3). Their lids were attached by using strapping tape at both ends of the container, strapping them girthwise. The preparation to fill the containers took approximately 3 minutes once the

container was removed from the chamber. Once the preparation was complete, the containers were dropped in accordance with the above test procedure. To ensure the containers were tested at the correct temperature, only one container was removed from the chamber, prepared with a test load and lid, and dropped at a time.

The containers were dropped 30 inches onto the drop tester steel plate. One drop was made on each face (excluding the top), corner, and edge (Procedure A) for a total of 25 drops. Thirteen drops (four corners, six edges, two sides, and the bottom) were made at +140°F. Twelve drops (using opposite corners, edges, and sides to the 140°F drop) were made at -20°F (Figures 4, 5, and 6).

Visual inspection was noted for each container. The results are as follows:

#### **Free-Fall Drop at +140°F**

All of the containers exhibited most of the same characteristics. All containers had rounding of corners and bowing of edges and sides. Each container exhibited slight creasing of the material after various drops (Figures 7, 8, 9, and 10).

Notable differences in performance are listed below.

Co A, Container 1:

1. After drop on corner B4-B5, minor delamination occurred.

Co A, Container 2:

1. After drop on edge T7-T8, the end of the lid protruded through the handle area on face 5-6 (Figure 11).

Co B Container:

1. After drop on edge 1-8, three of the ultrasonically-fused welds separated from face 5-6, disconnecting the right end flap from face 5-6 (Figure 12).
2. After drop on face 3-4, the top, right ultrasonically-fused weld on the end flap of face 1-2 separated from face 1-2 (Figure 13).

Co C Container:

1. After drop on corner T6-T7, edges 5T-6T and 1T-2T were bent considerably (Figure 14).
2. After drop on edge 4-5, edge 5T-6T was bent further.
3. After drop on edge T7-T8, the end of the lid popped through the handle area on face 5-6 (Figure 15).

Note: When Co A, Container 1 was removed from the environmental chamber, it was apparent that it had increased in yellow coloration due to accelerated aging of the glue.

Co A, Container 1, Co A, Container 2, and Co C Container appeared usable after the high-temperature drops; however, Co B Container was beginning to disassemble and may have become inadequate for its normal use.

The damage to Co B Container which resulted during these drops is classified as a major defect according to USPS-T-1155C, United States Postal Service Specification Test Procedures for Polyethylene Mail Tray.

### **Free-Fall Drop at -20°F**

The same containers were used for the cold-temperature drops, utilizing the corners, edges, and faces not used for the high-temperature drops.

All of the containers exhibited most of the same characteristics. All containers had rounding of corners and bowing of edges and sides. Each container exhibited slight creasing of the material after various drops (Figures 16, 17, 18, 19).

Notable differences in performance are listed below.

Co A, Container 1:

1. After drop on corner T4-T5, the end of the lid protruded through the handle area on face 5-6 (Figure 20).
2. After all drops were completed, the lower, right ultrasonically-fused weld on the end flap of face 1-2 had separated from face 1-2 (Figure 21).

Co A, Container 2:

1. After drop on edge T3-T4, the end of the lid protruded through the handle area on face 5-6 (Figure 22).

Co B Container:

1. After drop on corner B6-B7, the right end flap on face 5-6 was separated further from face 5-6 (Figure 23).
2. After drop on corner T4-T5, the end of the lid protruded through the handle area on face 5-6 (Figure 24).
3. After drop on edge T1-T2, the top, left ultrasonically-fused weld on the end flap of face 1-2 became loose.
4. After drop on side 5-6, the left, middle and left, bottom ultrasonically-fused welds on the end flap of face 1-2 separated from face 1-2 (Figure 25).

Co C Container:

1. After drop on corner T1-T8, the top, right ultrasonically-fused weld on the end flap of face 1-2 became loose.
2. After drop on corner T4-T5, the plastic cracked in the middle of edge 5T-6T, and the top left and right ultrasonically-fused welds on the end flap of face 5-6 became loose (Figure 26).
3. After drop on edge T3-T4, the steel rod in edge 5T-6T broke in half at a weld joint and protruded through the plastic (Figure 27).

Co A, Container 1 and Co A, Container 2 appeared usable after the low-temperature drops; however, Co B Container had disassembled further and may have become inadequate for its normal use. Also, Co C Container became unusable due to the protruding metal from the top of the handle on face 5-6.

According to USPS-T-1155C, Co A, Container 1, Co B Container, and Co C Container developed major defects during these drops.

After both the high-temperature and low-temperature drops were completed, Co A, Container 1 and Co A, Container 2 appeared usable. Co B Container's use appeared questionable and Co C Container was unusable.

**TEST SEQUENCE 4** - FED-STD-101C, Method 5019.1, Vibration (Repetitive Shock) Test.

<u>Equipment</u>	<u>Manufacturer</u>	<u>Model</u>	<u>Ser#</u>	<u>Cal Exp</u>
Vibration Machine	L.A.B. CORP.	5000-96 B	56801	N/A

The test was conducted in accordance with FED-STD-101C, Method 5019.1, at ambient temperature. Containers used for the drop tests were replaced; new containers were used for the Repetitive Shock Test.

The four containers were loaded with 30 lb. of sand and lids attached in the same manner as in the drop tests (Figure 28). The containers were placed on the vibration table. Restraints were utilized that would prevent the containers from sliding off the table or sliding into each other (Figures 29 and 30). The containers were allowed unrestricted movement from the centered position on the table about 1/2 inch in any horizontal direction.

The table frequency was increased from 0.0 Hertz (Hz) until the container left the table surface. At 4.6 Hz input vibration frequency, one inch double amplitude, a 1/16 inch thick bar could be slid freely between table and container under all points of the container. This condition was maintained for a period of two hours.

Visual inspection revealed no damage to any of the containers or their contents (Figures 31, 32, 33, and 34).

**TEST SEQUENCE 5 - MIL-STD-648B, 5.8.3 Hoisting Fittings Strength Test.**

The following equipment was utilized:

<u>Equipment</u>	<u>Manufacturer</u>	<u>Model</u>	<u>Ser#</u>	<u>Cal Exp</u>
Hoist	Coffing	3 Ton	SRD-112-CP	N/A

Containers used for the Repetitive Shock test were also used for the Hoist Fitting Strength Test. A 156.25 pound load, representing at least five times the 31.25 pound gross container weight, was placed on each container. The test load consisted of 156.25 pounds of bags of sand.

The containers were lifted, one at a time, completely off the ground for 5 minutes utilizing each handle (Figure 35).

All of the containers exhibited most of the same characteristics. Due to the pressure of the hoist strap and the weight of the load, all containers had their handles bowed inward, their sides bowed outward, and had some wrinkling of the material (Figures 36, 37, 38, and 39).

Notable differences in performance are listed below.

Co B Container:

1. The inner, right ultrasonically-fused weld, when looking at the handle from the inside of the container, on the handle of face 5-6, separated from face 5-6 (Figure 40).

All containers appeared usable after the test.

**TEST SEQUENCES (MAIL TRAY MATERIAL)**

**TEST SEQUENCE 1 - Types of Material.**

See paragraph, **Container and Material Description**, page 1.

**TEST SEQUENCE 2 - MIL-P-83668A, paragraph 4.5.4, Basis Weight.**

<u>Equipment</u>	<u>Manufacturer</u>	<u>Ser#</u>	<u>Cal Exp</u>
Digital Caliper	Mitutoyo	7001683	N/A
Beam Balance	OHAUS	1119	22 Nov 93

Ten test specimens were cut to 10 in. x 10 in., for three of the four materials, from 25 in. x 25 in. plastic board sheets. Due to the inability to obtain 25 in. x 25 in. plastic board sheets of Co A, Material 1 material, ten 10 in. x 10 in. specimens were cut from the bottom of Co A, Container 1 containers. Basis weight, the ratio of mass per area, was then calculated for each specimen. The Basis Weight was calculated as the average of the ten specimens.

Basis Weight measurements were calculated for use in the Flute T-Peel Strength Test only. Individual Basis Weight measurements were not compared to the Basis Weight specified by the manufacturers.

<u>Material</u>	<u>Basis Weight</u>
Co A, Material 1	0.152 lb./ft <sup>2</sup>
Co A, Material 2	0.160 lb./ft <sup>2</sup>
Co B Material	0.171 lb./ft <sup>2</sup>
Co C Material	0.162 lb./ft <sup>2</sup>

**TEST SEQUENCE 3** - MIL-P-83668A, paragraph 4.5.5, Thickness.

<u>Equipment</u>	<u>Manufacturer</u>	<u>Ser#</u>
Digital Caliper	General/MG	272350

An overall thickness of each material was calculated, by the following method, solely for comparing the materials to each other. Thickness measurements were not compared to manufacturer-specified thicknesses.

Ten specimens, 3 in. x 5 in., for three of the four materials, were cut from 25 in. x 25 in. plastic board sheets. Due to the inability to obtain 25 in. x 25 in. plastic board sheets of Co A, Material 1 material, ten 3 in. x 5 in. specimens were cut from the sides of Co A, Container 1 containers. The thickness of each specimen was measured at five non-overlapping points. The thickness of each specimen was calculated as the average of the five measurements. The thickness of each material was calculated as the average of the ten specimen averages.

<u>Material</u>	<u>Thickness</u>
Co A, Material 1	0.143 in.
Co A, Material 2	0.162 in.
Co B Material	0.157 in.
Co C Material	0.171 in.

**TEST SEQUENCE 4 - MIL-P-83668A, paragraph 4.5.6, Bending Qualities.**

Two test specimens, 10 in. x 10 in., from each material, were scored parallel and perpendicular to the direction of the corrugated medium (Figure 41). The test specimens were then folded 180° toward one facing and 180° toward the other along the scoreline both parallel and perpendicular to the direction of the corrugated medium. The specimens were inspected for breaks or cracks after folding. Cracks or breaks occurring at the intersection of score lines were discarded.

No visible damage occurred to any of the specimens.

**TEST SEQUENCE 5 - MIL-P-83668A, paragraph 4.5.7, Flute T-Peel Strength Test.**

<u>Equipment</u>	<u>Manufacturer</u>	<u>Ser#</u>	<u>Cal Exp</u>
Tensile-Compression Tester	Instron	1597	N/A
Tensile Load Cell	Instron	A414	N/A
Data Acquisition System	N/A	N/A	N/A

Ten test specimens, 11 in. long, were cut from 25 in. x 25 in. sheets of each material. Due to the lack of glued material, the glued samples were cut from the bottom of existing mail trays. The width of each specimen was cut such that each facing included exactly five flute peaks. A band saw was used to separate the facings at one end to a length of 3 in. by cutting through the corrugations, being careful not to damage the facings. Using a tension testing machine, a load was applied at a constant rate of 1 in. per minute along a line parallel to the specimen length (figures 42 and 43). The test was continued for a minimum of 2.5 in. of separation. Due to constraints of the tension testing machine, the length of separation, stated in MIL-P-83668A, was decreased from 6 in. to 2.5 in. The change did not appear to have any significance on the test results.

The load recorded for peel strength is the load recorded after the initial peak is reached (i.e., when the load recorded reflects the force required for separation) or the load required for the one of the facings to rupture.

The basis weight of each material required a peel strength of 35 pounds.

Co A, Materials 1 and 2, and Co C Material had peel strengths of under 35 lb:

Co A Material 1: Peel Strength measured 5 lb.  
Co A Material 2: Peel Strength measured 2 lb.  
Co C Material : Peel Strength measured 10 lb.

Co B Material did not peel. It appeared as though the bonding of the layers was so strong that one facing would rupture before peeling would start (Figure 44). This occurred at 58 lb.

The initial peak force measured for Co A, Material 1 was 21 lb.  
The initial peak force measured for Co A, Material 2 was 39 lb.  
The initial peak force measured for Co C Material was 32 lb.

**TEST SEQUENCE 6** - MIL-STD-810E, method 507.3, Humidity Test.

<u>Equipment</u>	<u>Manufacturer</u>	<u>Ser#</u>	<u>Cal Exp</u>
Temperature and Humidity Test Chamber	Blue-M	FRP103	30 Sep 93

Ten specimens from each material were cut to 5 in. x 5 in. and conditioned at  $+140^{\circ}\text{F} \pm 5^{\circ}\text{F}$  and  $90\% \text{ RH} \pm 5\% \text{ RH}$  for 168 hours. The samples were then inspected for any visible damage such as warping or delamination.

The results are as follows:

**Co A, Material 1**

When the samples were removed from the humidity chamber, it was apparent that their color had yellowed considerably. Six of the ten samples had started to delaminate (Figure 45). Of the four samples which had not started to delaminate, two were easily delaminated by pulling the layers apart by hand, using little effort. (Figure 46). The two remaining samples were not physically separated in order to determine if the glue would hold up after completely cooling and drying. The two remaining samples could not be delaminated by hand after cooling and drying.

All of the samples had warped slightly.

**Co A, Material 2**

All of the samples had warped slightly, but no other visible damage had occurred (Figure 47).

**Co B Material**

All of the samples had warped considerably, but no other visible

damage had occurred (Figure 48).

### **Co C Material**

All of the samples warped slightly. Of all of the materials, this material warped the least. No other visible damage had occurred (Figure 49).

NOTE: The Flatness Test, MIL-P-83668A, paragraph 4.5.8, was not performed due to the inability to obtain new Co A, Material 1 material.

### **CONCLUSION**

The mail tray tests and mail tray material tests were conducted solely for comparison purposes. The tests were not used to either pass or fail the mail trays or mail tray material. To assist with this comparison, the following events are highlighted:

The container drop tests resulted in three of the four mail trays acquiring major defects according to USPS-T-1155C. The only mail tray which did not acquire a major defect was Co A, Container 2.

The container vibration test resulted in no damage to any of the containers.

The Hoist-Fittings Strength Test resulted in one tray, Co B Container, acquiring a major defect according to USPS-T-1155C.

The Basis Weight was determined for comparison purposes and for use in the Flute T-Peel Strength Test. The Basis Weight was not compared to the manufacturer-specified basis weight.

The Thickness test was used for comparison purposes only.

The Bending Qualities test resulted in no damage to any of the material specimens.

The Flute T-Peel Strength Test resulted in only one specimen, Co B Material, meeting the specified requirement of a 35 lb. peel strength.

The Humidity Test resulted in slight warping of all of the specimens. In addition, Co A, Material 2 delaminated considerably.

A summary of the mail tray test results and the mail tray material test results are located on the following pages, in Table 1 and Table 2, respectively.

TABLE 1 - Tray Summary

CONTAINER	WEIGHT	DROP TEST, +140°F	DROP TEST, -25°F	VIBRATION TEST	HOIST FITTINGS STRENGTH TEST
<b>Co A, Container 1</b>	805.75 gm	1. Rounded corners 2. Bowed edges and sides 3. Slight material creasing	1. Rounded corners 2. Bowed edges and sides 3. Slight material creasing 4. Lid protrusion through handle area 5. Total of one separated weld	No damage	1. Handles bent inward 2. Sides bowed outward 3. Wrinkling of material
<b>Co A, Container 2</b>	898.33 gm	1. Rounded corners 2. Bowed edges and sides 3. Slight material creasing 4. Lid protrusion through handle area	1. Rounded corners 2. Bowed edges and sides 3. Slight material creasing 4. Lid protrusion through handle area	No damage	1. Handles bent inward 2. Sides bowed outward 3. Wrinkling of material
<b>Co B Container</b>	857.67 gm	1. Rounded corners 2. Bowed edges and sides 3. Slight material creasing 4. Total of four separated welds	1. Rounded corners 2. Bowed edges and sides 3. Slight material creasing 4. Lid protrusion through handle area 5. Total of two separated welds	No damage	1. Handles bent inward 2. Sides bowed outward 3. Wrinkling of material 4. Total of one separated weld
<b>Co C Container</b>	829.00 gm	1. Rounded corners 2. Bowed edges and sides 3. Slight material creasing 4. Two edges bent considerably 5. Lid protrusion through handle area	1. Rounded corners 2. Bowed edges and sides 3. Slight material creasing 4. Steel rod broke at a weld joint	No damage	1. Handles bent inward 2. Sides bowed outward 3. Wrinkling of material

TABLE 2 - Material Summary

MATERIAL	BASIS WEIGHT	THICKNESS	BENDING BENDING QUALITIES	FLUTE T-PEEL STRENGTH TEST	HUMIDITY TEST
Co A, Material 1	0.152 lb./sq-ft	0.1429 in.	No damage	5 lb.	1. Slight warping 2. Delamination
Co A, Material 2	0.160 lb./sq-ft	0.1621 in.	No damage	2 lb.	Slight warping
Co B Material	0.171 lb./sq-ft	0.1569 in.	No damage	10 lb.	Slight warping
Co C Material	0.162 lb./sq-ft	0.1714 in.	No damage	58 lb.	Slight warping

## RECOMMENDATIONS

1. The glued tray material delaminated substantially during the Humidity test. Recommend that the glued mail trays not be utilized in high-temperature, high-humidity environments. Recommend that USPS-T-1154B, United States Postal Service Specification Test Procedures for Polyethylene Mail Tray Material, paragraph 3.1, be worded such that the trays be manufactured by either a heat-fusion process or the fusion-bonding process.

2. The Flute T-Peel Strength requirement of 35 lb. appeared to have little effect on mail tray performance. Recommend the test methods outlined in the mail tray test plan on page 21 be used as first article testing for future mail tray procurements.

APPENDIX A  
TEST SEQUENCES

AIR FORCE PACKAGING EVALUATION ACTIVITY (Container Test Plan)						AFPEA PROJECT NUMBER 92-119	
CONTAINER SIZE (L x W x D) (INCHES)		WEIGHT (LBS)		CUBE (CU. FT.)	QUANTITY	DATE	
INTERIOR:	EXTERIOR:	GROSS:	ITEM:				
As noted	As noted	As noted	As noted	As noted	4	05 OCT 92	
ITEM NAME				MANUFACTURER			
				As noted			
CONTAINER NAME					CONTAINER COST		
Mail Tray							
PACK DESCRIPTION							
Plastic board (Type II - Laminated Corrugated)							
CONDITIONING							
Ambient testing unless otherwise specified							
TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS	CONTAINER ORIENTATION	INSTRUMENTATION			
1. <u>MEASUREMENT AND WEIGHT</u>							
A. Co A, Container 1 - glued, 3-layer							
1. Exterior		Top: 18.16 in. x 13.11 in.	(1 x w)				
		Middle: 16.43 in. x 11.85 in.	(1 x w)				
		Bottom: 15.09 in. x 11.13 in.	(1 x w)				
		Height: 11.34 in.					
2. Interior		Top: 16.98 in. x 12.15 in.	(1 x w)				
		Middle: 15.84 in. x 11.63 in.	(1 x w)				
		Bottom: 14.85 in. x 10.95 in.	(1 x w)				
		Height: 11.21 in.					
3. Maximum Cube:		1.57 ft <sup>3</sup>					
4. Weight Item:		1.78 lb					
Gross:		31.78 lb					
B. Co A, Container 2 - fusion bonded, 5-layer							
1. Exterior		Top: 18.18 in. x 13.11 in.	(1 x w)				
		Middle: 16.52 in. x 11.94 in.	(1 x w)				
		Bottom: 15.15 in. x 11.11 in.	(1 x w)				
		Height: 11.43 in.					
2. Interior		Top: 17.02 in. x 12.26 in.	(1 x w)				
		Middle: 15.80 in. x 11.78 in.	(1 x w)				
		Bottom: 14.71 in. x 10.80 in.	(1 x w)				
		Height: 11.30 in.					
3. Maximum Cube:		1.58 ft <sup>3</sup>					
4. Weight Item:		1.98 lb					
Gross:		31.98 lb					
COMMENTS:							
PREPARED BY: Susan J. Misra, Materials Engineer				APPROVED BY: Larry A. Wood Materials Engineering, AFPEA			

AIR FORCE PACKAGING EVALUATION ACTIVITY (Container Test Plan)						AFPEA PROJECT NUMBER 92-119	
CONTAINER SIZE (L x W x D) (INCHES)		WEIGHT (LBS)		CUBE (CU. FT.)	QUANTITY	DATE	
INTERIOR:	EXTERIOR:	GROSS:	ITEM:				
As noted	As noted	As noted		As noted	4	05 OCT 92	
ITEM NAME				MANUFACTURER			
				As noted			
CONTAINER NAME					CONTAINER COST		
Mail Tray							
PACK DESCRIPTION							
Plastic board (Type II - Laminated Corrugated)							
CONDITIONING							
Ambient testing unless otherwise specified							
TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS	CONTAINER ORIENTATION	INSTRUMENTATION			
1.	<u>MEASUREMENT AND WEIGHT (Con't)</u>						
	C. Co B Container - heat fused, 3-layer						
	1. Exterior	Top: 18.15 in. x 13.13 in.	(1 x w)				
		Middle: 16.64 in. x 11.90 in.	(1 x w)				
		Bottom: 15.18 in. x 11.20 in.	(1 x w)				
		Height: 11.35 in.					
	2. Interior	Top: 16.96 in. x 12.19 in.	(1 x w)				
		Middle: 15.85 in. x 11.81 in.	(1 x w)				
		Bottom: 14.88 in. x 10.91 in.	(1 x w)				
		Height: 11.21 in.					
	3. Maximum Cube:	1.57 ft <sup>3</sup>					
	4. Weight Item:	1.89 lb					
	Gross:	31.89 lb					
	D. Co C Container - heat fused, 3-layer						
	1. Exterior	Top: 18.30 in. x 13.31 in.	(1 x w)				
		Middle: 16.64 in. x 12.04 in.	(1 x w)				
		Bottom: 15.27 in. x 10.93 in.	(1 x w)				
		Height: 11.37 in.					
	2. Interior	Top: 17.12 in. x 12.26 in.	(1 x w)				
		Middle: 15.78 in. x 11.83 in.	(1 x w)				
		Bottom: 14.72 in. x 10.50 in.	(1 x w)				
		Height: 11.22 in.					
	3. Maximum Cube:	1.60 ft <sup>3</sup>					
	4. Weight Item:	1.83 lb					
	Gross:	31.83 lb					
COMMENTS:							
PREPARED BY: Susan J. Misra, Materials Engineer				APPROVED BY: Larry A. Wood Materials Engineering, AFPEA			

AIR FORCE PACKAGING EVALUATION ACTIVITY (Container Test Plan)						AFPEA PROJECT NUMBER	
CONTAINER SIZE (L x W x D) (INCHES) INTERIOR:                      EXTERIOR:				WEIGHT (LBS) GROSS:                      ITEM:		CUBE (CU. FT.)	
As noted		As noted		As noted		As noted	
ITEM NAME						MANUFACTURER	
As noted						As noted	
CONTAINER NAME						CONTAINER COST	
Mail Tray							
PACK DESCRIPTION							
Plastic board (Type II - Laminated Corrugated)							
CONDITIONING							
Ambient testing unless otherwise specified							
TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS	CONTAINER ORIENTATION	INSTRUMENTATION			
2.	<u>ROUGH HANDLING TESTS (+140°F)</u> FED-STD-101 Method 5007.1 Rectangular Level B Procedure A	Free fall drop test. Drop height: 30 in. Condition at +140°F ± 5°F for a minimum of 24 hours. Load with 30 lb test.	One drop on each flat face (except top), edge and corner. Total of 25 drops.	Visual inspection			
3.	<u>ROUGH HANDLING TESTS (-20°F)</u> FED-STD-101 Method 5007.1 Rectangular Level B Procedure A	Free fall drop test. Drop height: 30 in. Condition at -20°F ± 5°F for a minimum of 24 hours. Load with 30 lb test.	One drop on each flat face (except top), edge and corner. Total of 25 drops.	Visual inspection			
4.	<u>REPETITIVE SHOCK TEST</u> FED-STD-101 Method 5019.1	Input excitation of 1-inch double amplitude. Frequency determined by 1/16 in. maximum clearance from table. Load with 30 lb test. Two hour test.		Visual inspection			
5.	<u>HOISTING FITTINGS STRENGTH TEST.</u> FED-STD-648B Para. 5.8.3	Add a 156.25 lb (est) in the loaded container. Lift off the floor using the two handles and hang for five minutes. There can be no damage or permanent deformation.		Visual inspection			
COMMENTS:							
TEST NOS. 5 and 6, ROUGH HANDLING TESTS (+140°F) and (-20°F): Note that the drop height has been changed due to standard usage of container.							
PREPARED BY:				APPROVED BY:			
Susan J. Misra, Materials Engineer				Larry A. Wood Materials Engineering, AFPEA			

AIR FORCE PACKAGING EVALUATION ACTIVITY (Container Test Plan)					AFPEA PROJECT NUMBER	
CONTAINER SIZE (L x W x D) (INCHES)			WEIGHT (LBS)		CUBE (CU. FT.)	
INTERIOR:		EXTERIOR:		GROSS:		ITEM:
As noted		As noted				
					QUANTITY	DATE
					4	05 OCT 92
ITEM NAME				MANUFACTURER		
Mail Tray Material				As noted		
CONTAINER NAME					CONTAINER COST	
PACK DESCRIPTION						
Plastic board (Type II - Laminated Corrugated)						
CONDITIONING						
Ambient testing unless otherwise specified						
TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS	CONTAINER ORIENTATION	INSTRUMENTATION		
1.	<u>MANUFACTURERS</u>	<u>- TYPES OF MATERIAL</u>				
A.	Co A, Material	1 - glued, 3 layer				
B.	Co A, Material	2 - fusion bonded, 5-layer				
C.	Co B Material	- heat fused, 3-layer				
D.	Co C Material	- heat fused, 3-layer				
2.	<u>BASIS WEIGHT</u> MIL-P-83668A Paragraph 4.5.4	Ratio of mass per area. Minimum of five test units from the same plastic board sheet with minimum dimensions of 10 in. x 10 in. Condition at +70°F ± 5°F and 50% relative humidity (RH) ± 5% RH for a minimum of 24 hours.			Measurement	
COMMENTS:						
PREPARED BY:				APPROVED BY:		
Susan J. Misra, Materials Engineer				Larry A. Wood Materials Engineering, AFPEA		

AIR FORCE PACKAGING EVALUATION ACTIVITY (Container Test Plan)						AFPEA PROJECT NUMBER 92-119	
CONTAINER SIZE (L x W x D) (INCHES)		WEIGHT (LBS)		CUBE (CU. FT.)	QUANTITY	DATE	
INTERIOR: As noted	EXTERIOR: As noted	GROSS:	ITEM:				
ITEM NAME Mail Tray Material				MANUFACTURER As noted			
CONTAINER NAME					CONTAINER COST		
PACK DESCRIPTION Plastic board (Type II - Laminated Corrugated)							
CONDITIONING Ambient testing unless otherwise specified							
TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS	CONTAINER ORIENTATION	INSTRUMENTATION			
3.	<u>THICKNESS</u> MIL-P-83668A Paragraph 4.5.5	Five test specimens, with minimum dimensions of 3 in. x 5 in., shall be cut from each sheet of plastic board. The thickness of each test specimen shall be measured at 5 non-overlapping points. Condition at +70°F ± 5°F and 50% RH ± 5% RH for a minimum of 24 hours.		Measurement			
4.	<u>BENDING QUALITIES</u> MIL-P-83668A Paragraph 4.5.6	Specimens with dimensions 11 in. x 11 in. shall be scored parallel and perpendicular to the direction of the corrugated medium. The test specimen shall then be folded 180° toward one facing and 180° toward the other along the scoreline both parallel and perpendicular to the direction of the corrugated medium. Condition at +70°F ± 5°F and 50% RH ± 5% RH for a minimum of 24 hours.		Visual inspection			
<b>COMMENTS:</b> TEST NO. 4, BENDING QUALITIES: Note that specimen size has been changed due to physical limitations.							
<b>PREPARED BY:</b> Susan J. Misra, Materials Engineer				<b>APPROVED BY:</b> Larry A. Wood Materials Engineering, AFPEA			

AIR FORCE PACKAGING EVALUATION ACTIVITY (Container Test Plan)					AFPEA PROJECT NUMBER	
CONTAINER SIZE (L x W x D) (INCHES)			WEIGHT (LBS)		CUBE (CU. FT.)	92-119
INTERIOR:		EXTERIOR:	GROSS:	ITEM:	QUANTITY	DATE
As noted		As noted			4	05 OCT 92
ITEM NAME				MANUFACTURER		
Mail Tray Material				As noted		
CONTAINER NAME					CONTAINER COST	
PACK DESCRIPTION						
Plastic board (Type II - Laminated Corrugated)						
CONDITIONING						
Ambient testing unless otherwise specified						
TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS	CONTAINER ORIENTATION	INSTRUMENTATION		
5.	FLUTE T-PEEL STRENGTH MIL-P-83668A Paragraph 4.5.7	Five test specimens shall be cut from each of two plastic board sheets so that no portion of the test specimens is within 3 in. of any of the sheet edges. Cut the width to include exactly five flute peaks on each facing. The test specimens shall be 11 in. long. Condition at $+70^{\circ}\text{F} \pm 5^{\circ}\text{F}$ and $50\% \text{ RH} \pm 5\% \text{ RH}$ for a minimum of 24 hours. Using a tension testing machine, apply a load at a constant rate of 1 in. per minute along a line parallel to the specimen length. The test shall be continued for a minimum of 6 in. of separation or until one of the facings ruptures.		Visual and dimensional inspection		
COMMENTS:						
TEST NO. 5, FLUTE T-PEEL STRENGTH: Note that specimen length has been changed due to physical limitations.						
PREPARED BY:				APPROVED BY:		
Susan J. Misra, Materials Engineer				Larry A. Wood Materials Engineering, AFPEA		

AIR FORCE PACKAGING EVALUATION ACTIVITY (Container Test Plan)						AFPEA PROJECT NUMBER	
						92-119	
CONTAINER SIZE (L x W x D) (INCHES)		WEIGHT (LBS)		CUBE (CU. FT.)	QUANTITY	DATE	
INTERIOR:		EXTERIOR:		GROSS:	ITEM:		
As noted		As noted				4	05 OCT 92
ITEM NAME				MANUFACTURER			
Mail Tray Material				As noted			
CONTAINER NAME						CONTAINER COST	
PACK DESCRIPTION							
Plastic board (Type II - Laminated Corrugated)							
CONDITIONING							
Ambient testing unless otherwise specified							
TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS	CONTAINER ORIENTATION	INSTRUMENTATION			
6.	<u>FLATNESS TEST</u> MIL-P-83668A Paragraph 4.5.8	Specimens with dimensions 11 in. x 11 in. shall be cut from the middle of the sheets. Condition at $+70^{\circ}\text{F} \pm 5^{\circ}\text{F}$ and $50\% \text{ RH} \pm 5\% \text{ RH}$ for a minimum of 24 hours. Place specimens on a flat surface and measure the maximum vertical distance from the surface to the underside of the specimen.		Visual and dimensional inspection			
7.	<u>HUMIDITY TEST</u> MIL-STD-810E Method 507.3	Specimens shall be 11 in. x 11 in. Test at $+140^{\circ}\text{F} \pm 5^{\circ}\text{F}$ and $90\% \text{ RH} \pm 5\% \text{ RH}$ for a minimum of 168 hours.		Visual and dimensional inspection			
COMMENTS:							
TEST NOS. 6 and 7, FLATNESS TEST and HUMIDITY TEST: Note that specimen size has been changed due to physical limitations.							
PREPARED BY:				APPROVED BY:			
Susan J. Misra, Materials Engineer				Larry A. Wood Materials Engineering, AFPEA			

APPENDIX B  
PHOTOGRAPHS

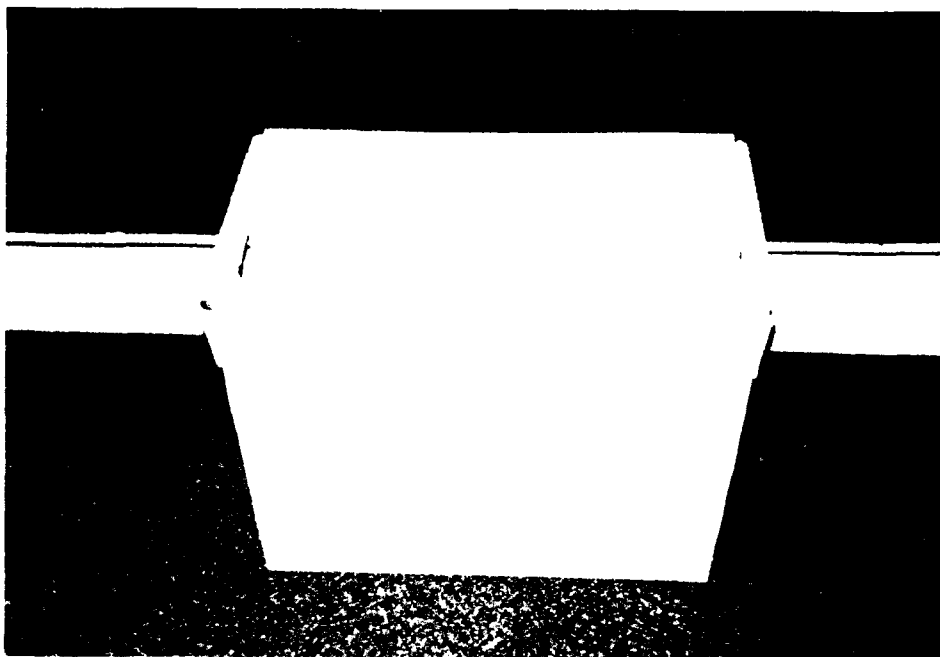


Figure 1. Standard-Type Mail Tray.

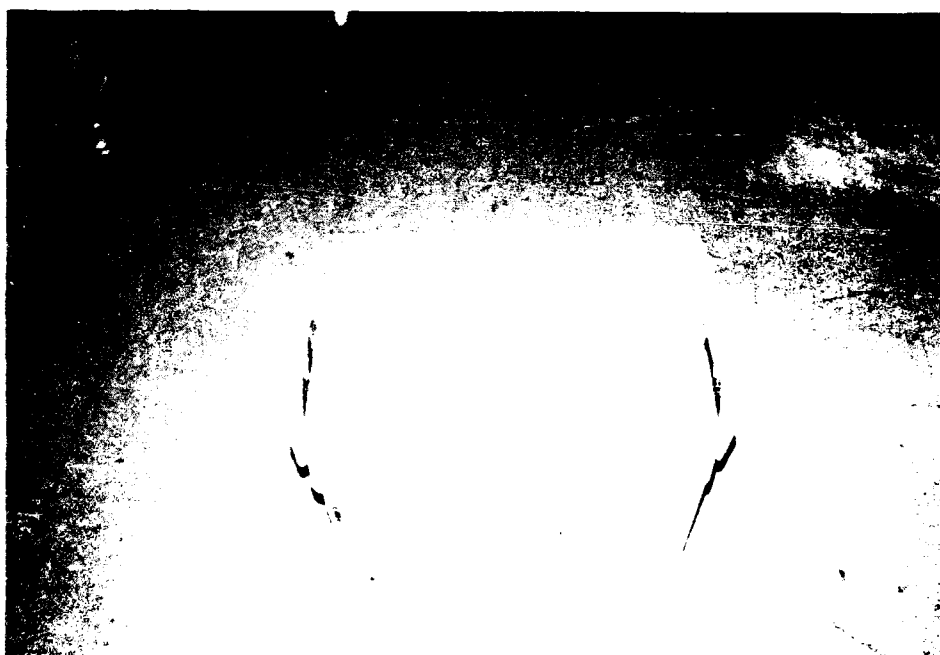


Figure 2. Standard-Type Mail Tray with Lid.



Figure 3. Test Load of 30 lbs. of White Lead Load.



Figure 4. Load of 30 lbs. of White Lead Load.

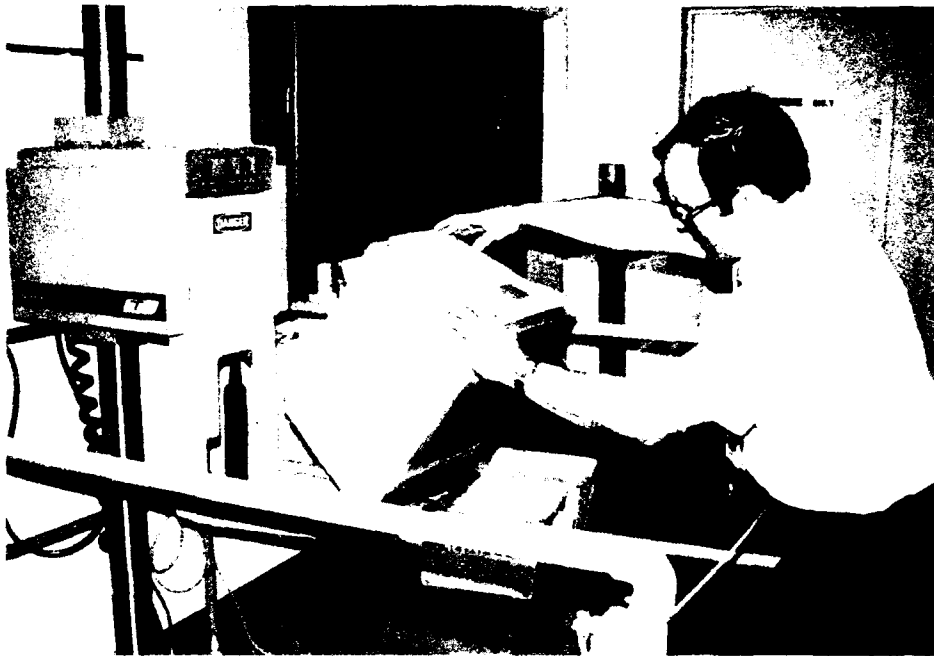


Figure 5. Rewinding Process.



Figure 6. Rewinding Process.

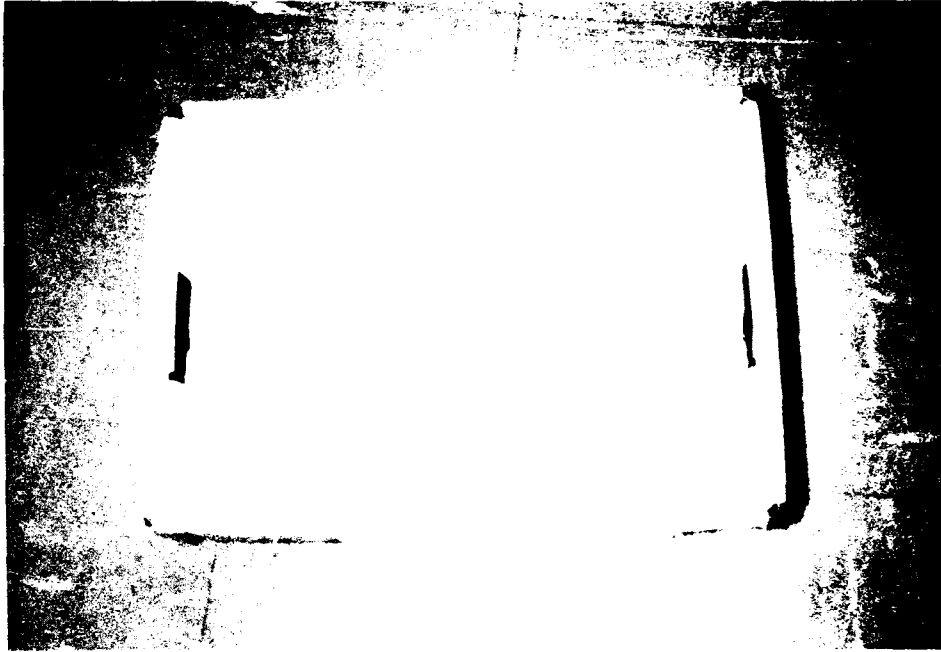


Figure 1. (A) Contaminated bottom layer of soil.

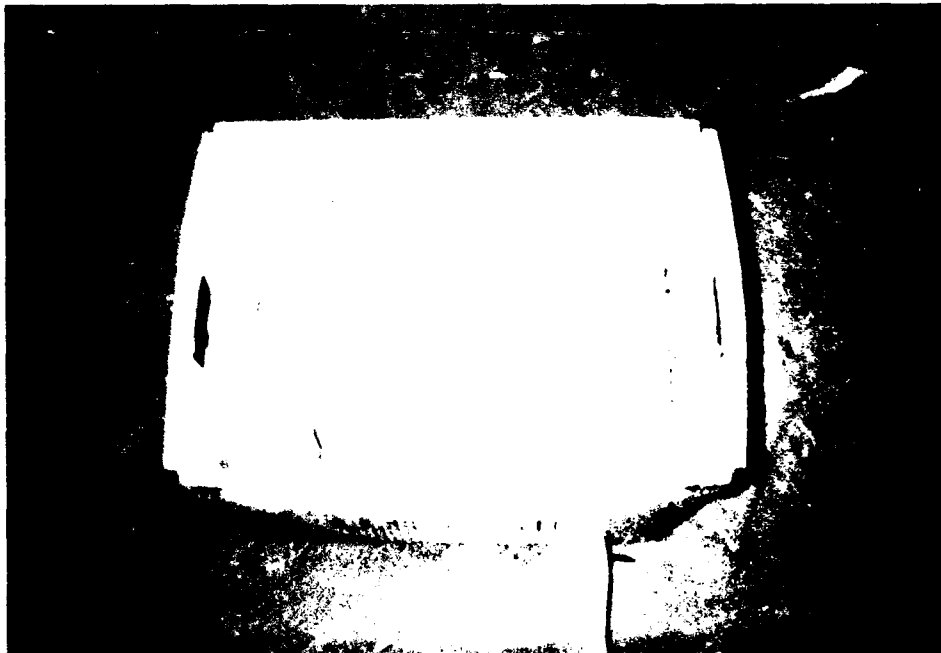


Figure 2. (A) Contaminated bottom layer of soil.

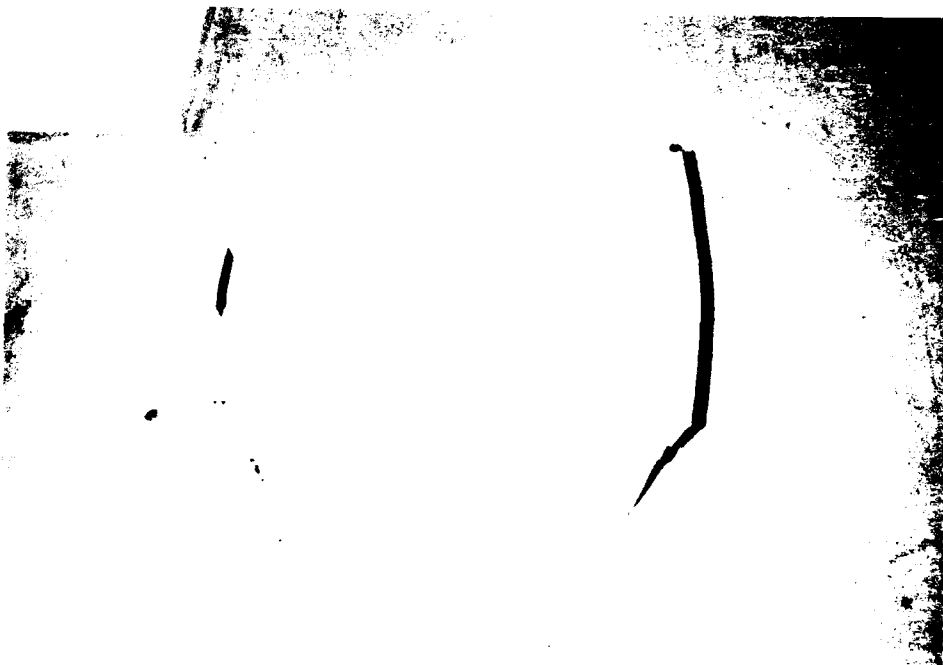
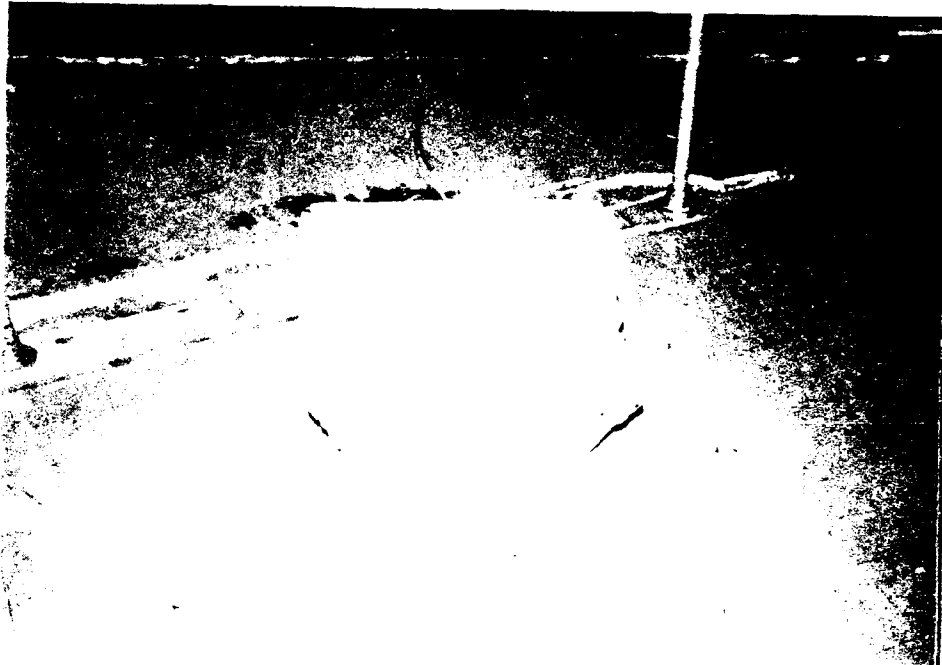




Figure 11. Co A, Container 2 after Drop on Corner To-T at +145°F.



Figure 12. Co B Container after Drop on Edge 1-8 at +145°F.



Figure 13. Photograph taken after 10 p.m. (March 10, 1968).

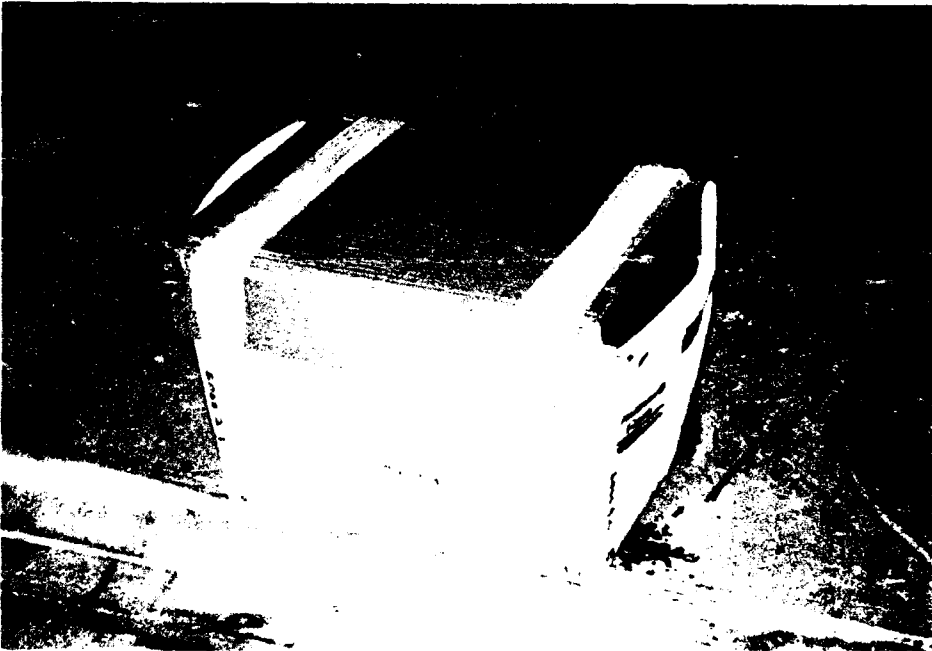
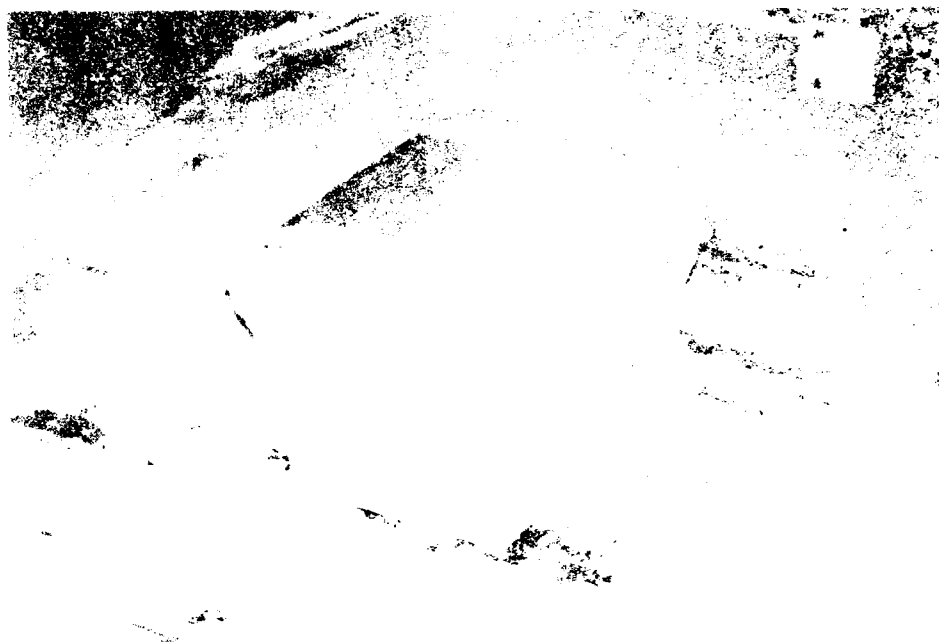
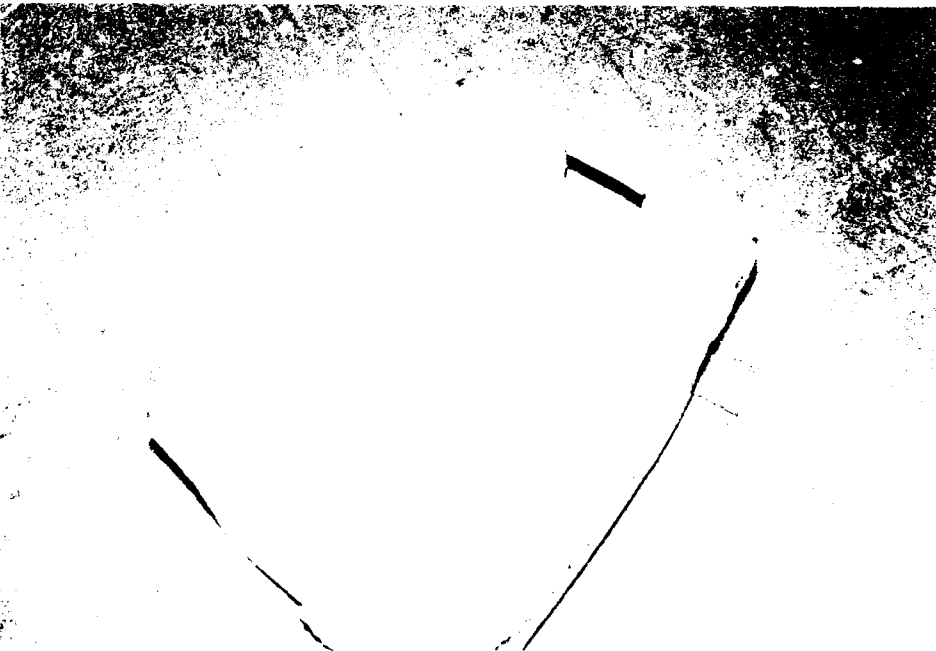
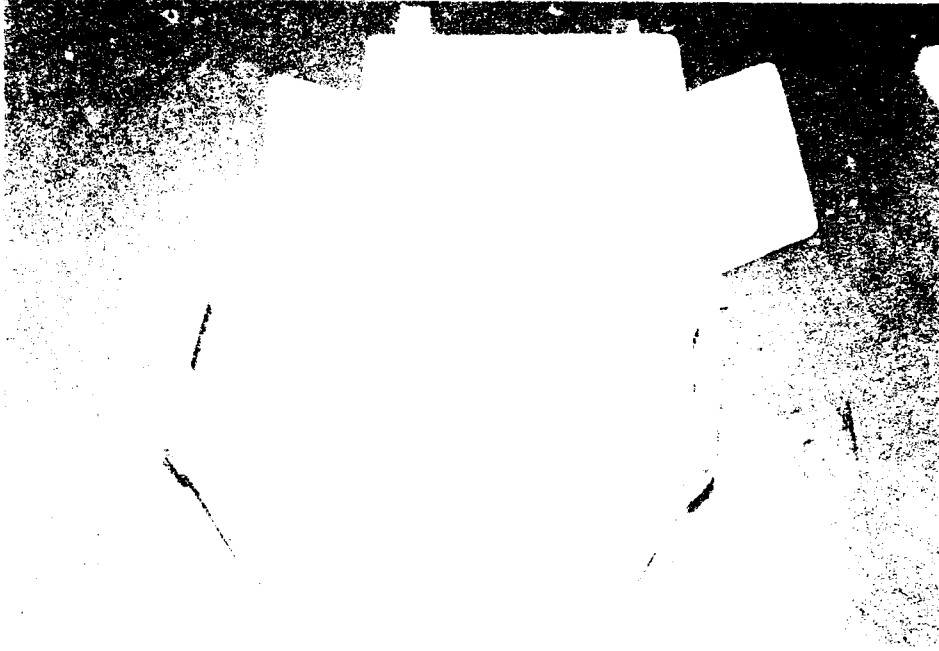


Figure 14. Photograph taken after 10 p.m. (March 10, 1968).





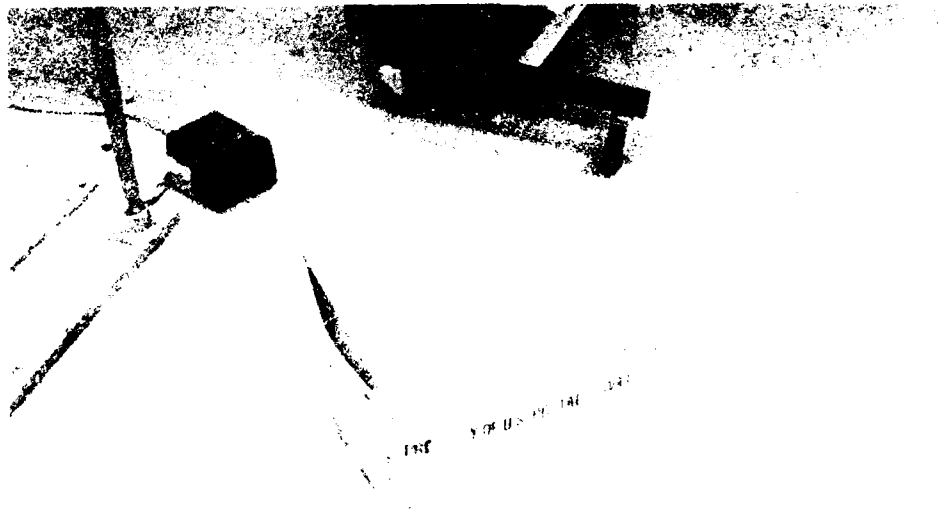
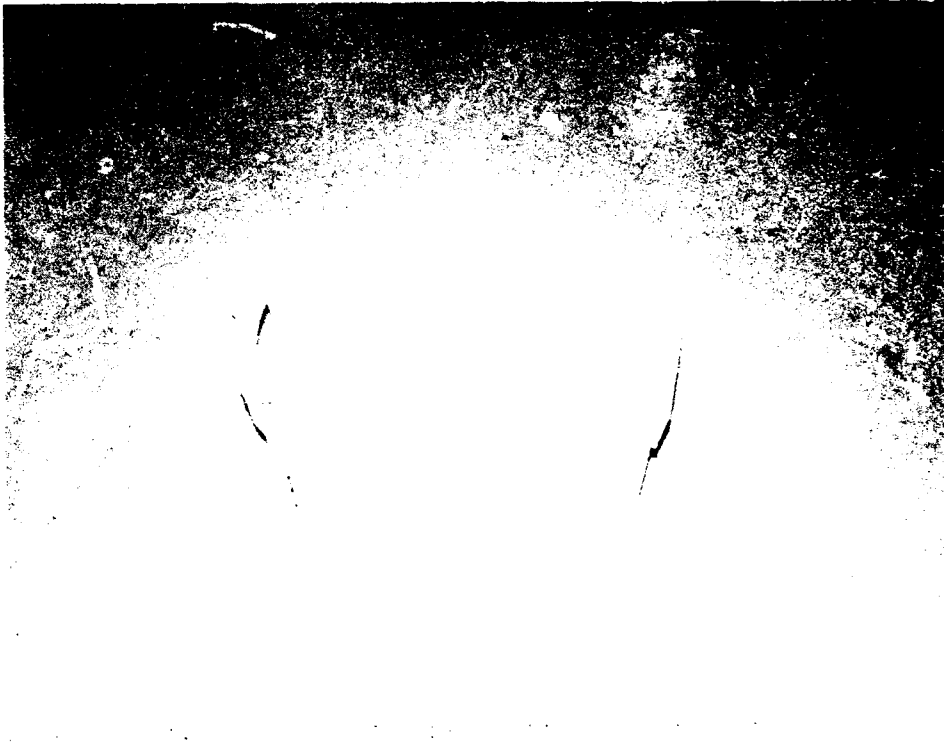




Figure 21. Co A, Container 1 after All Drops.

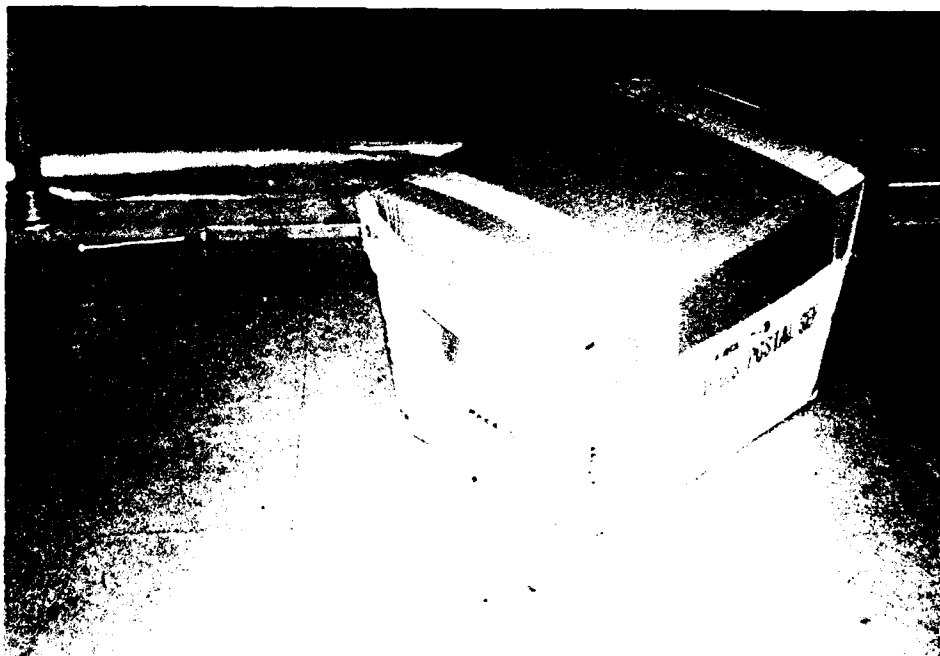
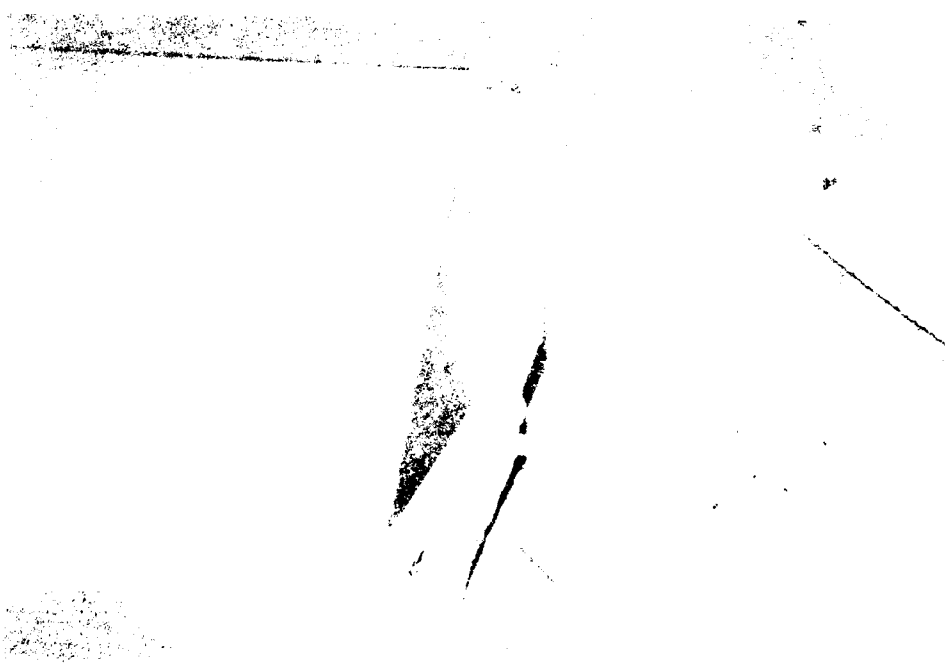
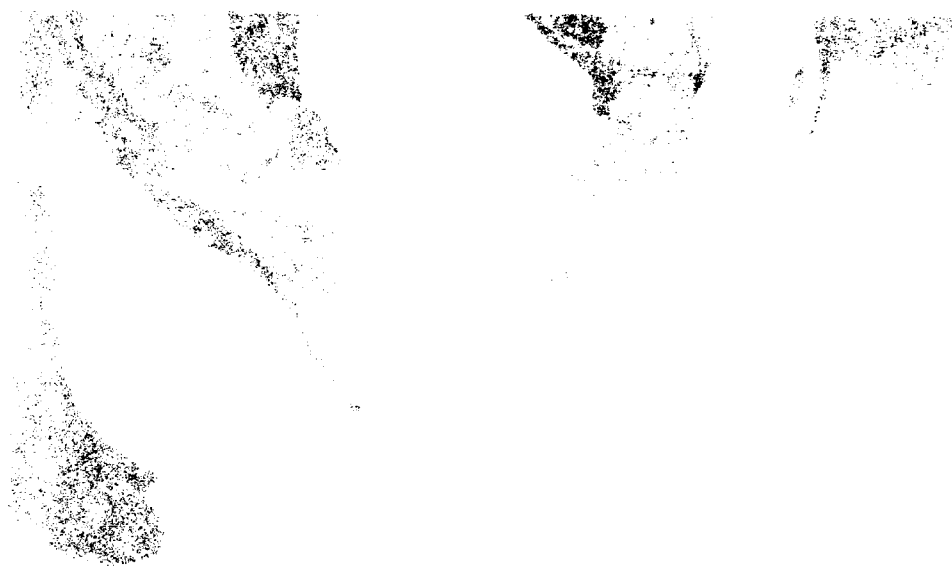


Figure 22. Co A, Container 2 after Drop on Edge T3 T4 or  
DROP.





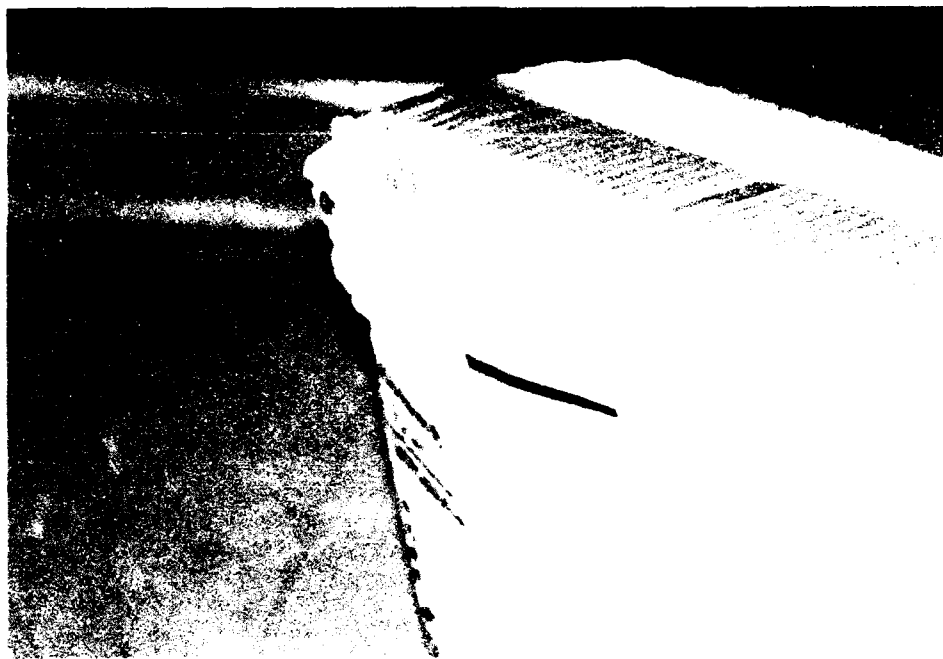


Figure 27. A. Contaminated area (Fig. 1, Plate 1) at 2000x.

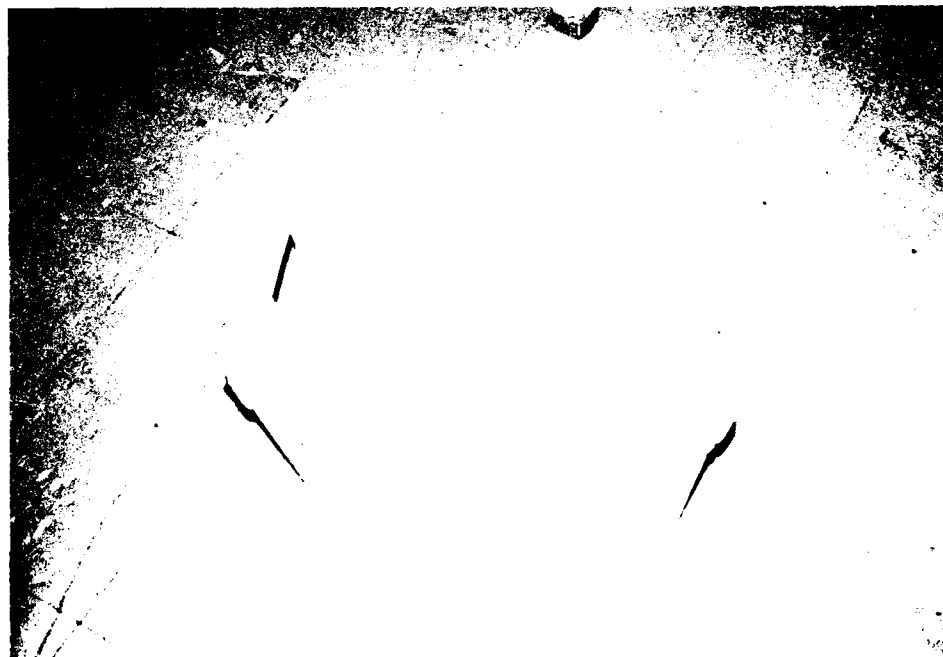


Figure 28. Vibration Test - Test Load of 50 lbs. at 2000x.

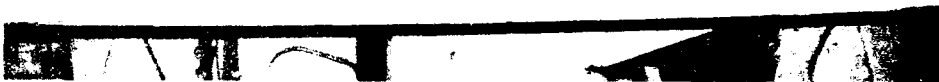
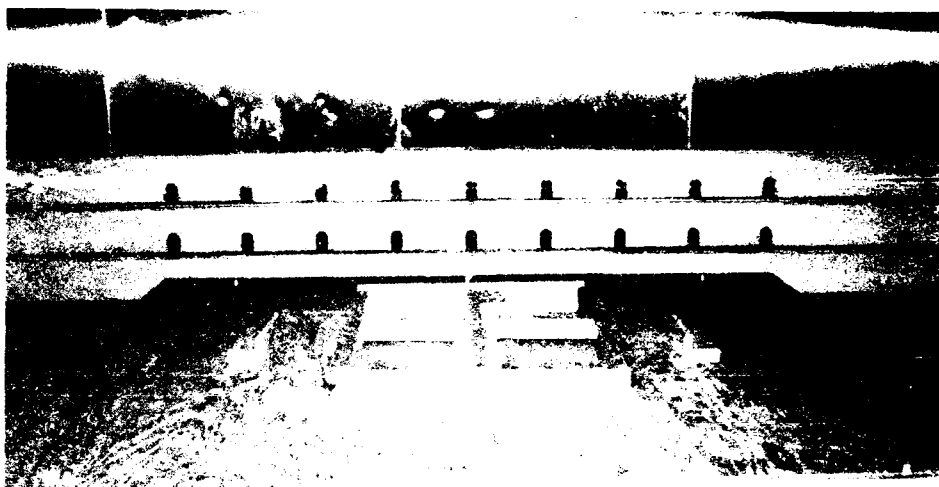


Figure 1. View of the dam from the upstream side.

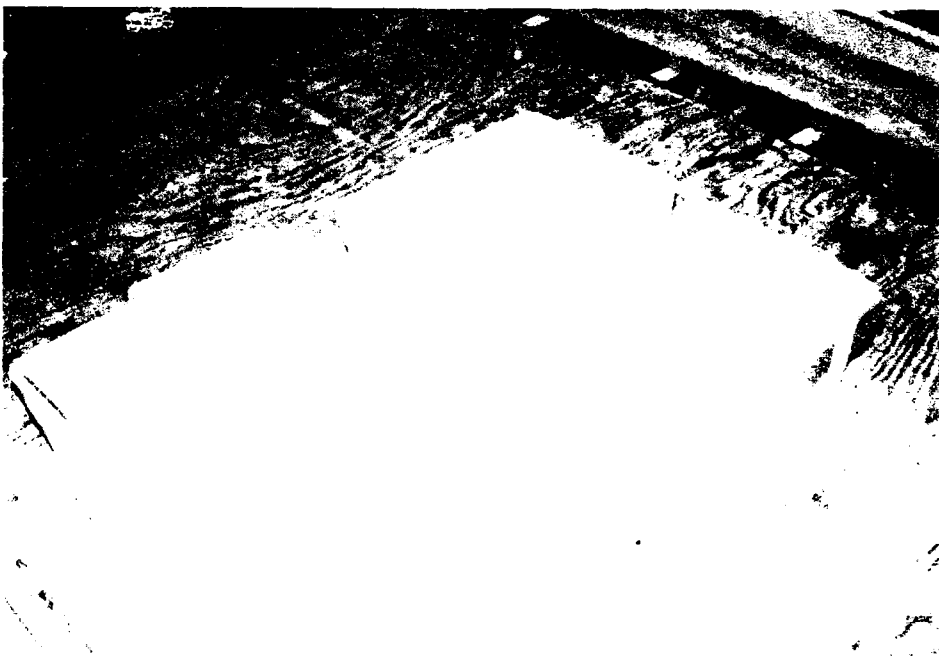


Figure 2. View of the dam from the downstream side.

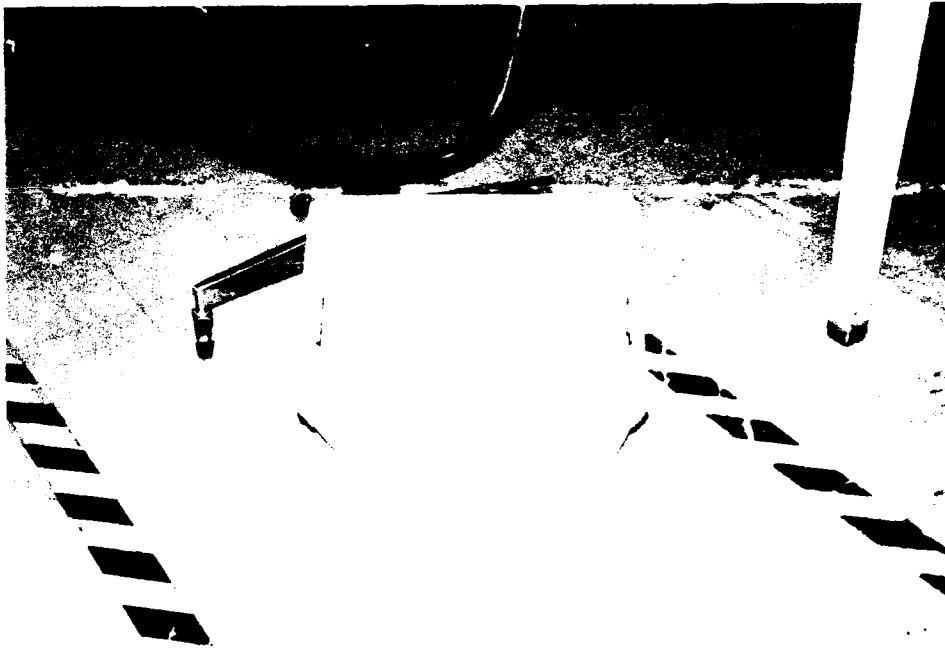


Figure 31. CC A, Container 1 after Vibration Test.



Figure 32. CC A, Container 1 after Vibration Test.



Figure 33. Co B Container after Vibration Test.



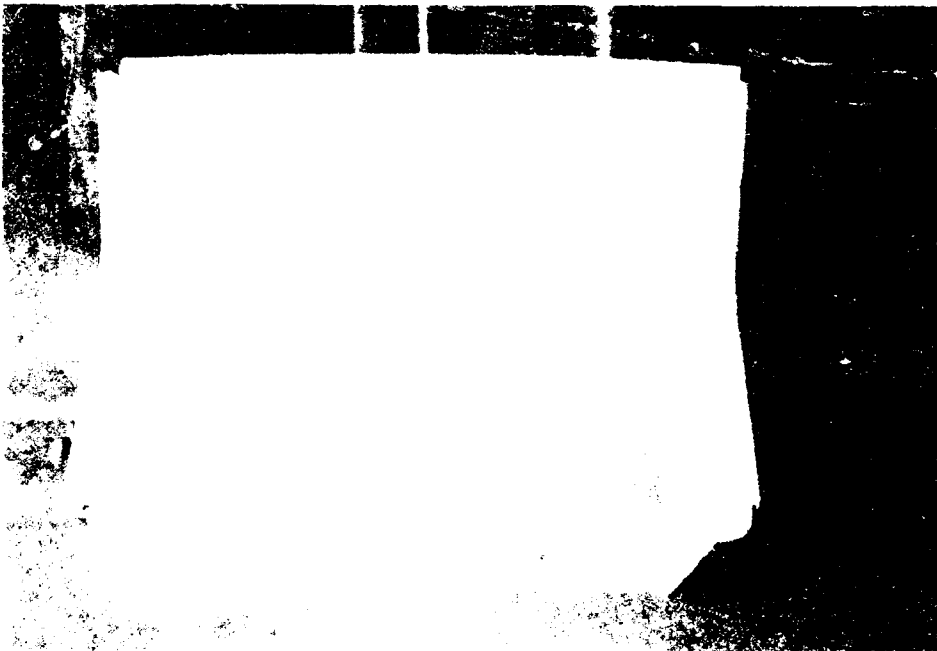
Figure 34. Co C Container after Vibration Test.



Figure 1. The object in the center of the image.



Figure 2. The object in the center of the image, viewed from a different angle.



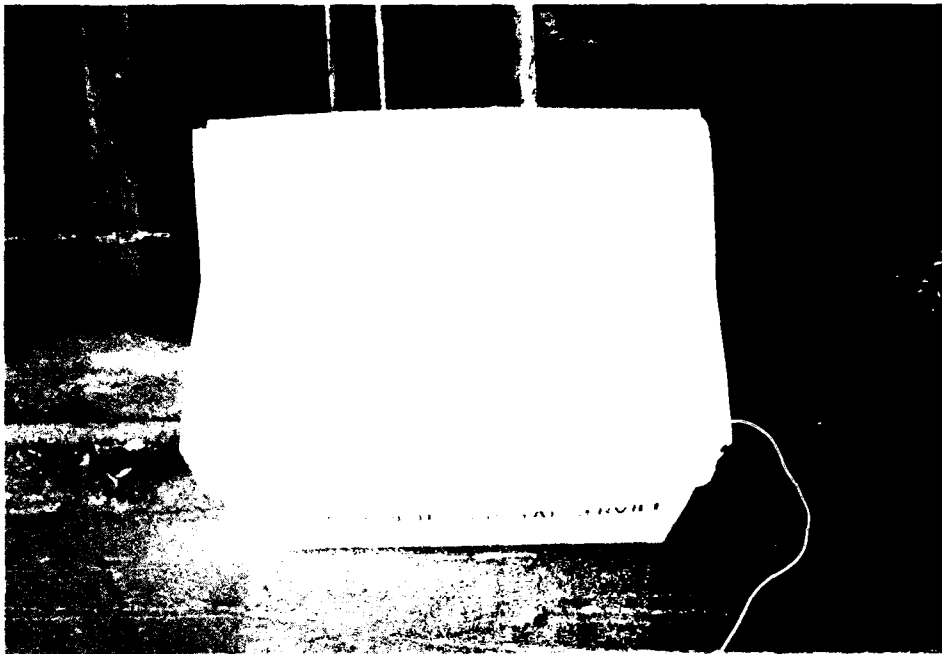


Figure 39. Co-C Container after H<sub>2</sub> and H<sub>2</sub>O<sub>2</sub> Strength Test.



Figure 40. Co-C Container Lower after H<sub>2</sub> and H<sub>2</sub>O<sub>2</sub> Strength Test.

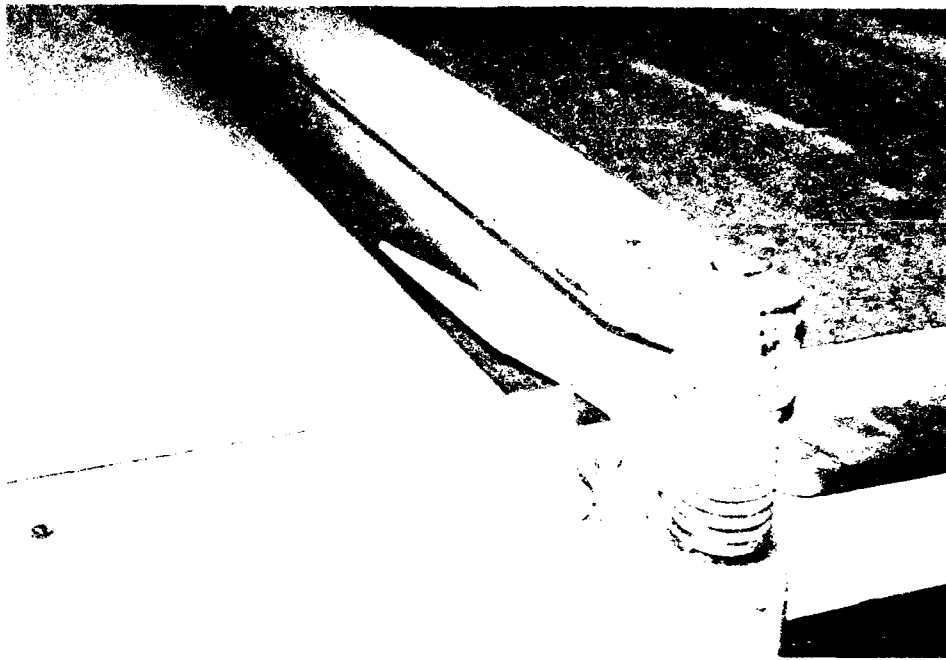


Figure 1. A close-up view of the mechanical component shown in the photograph above.

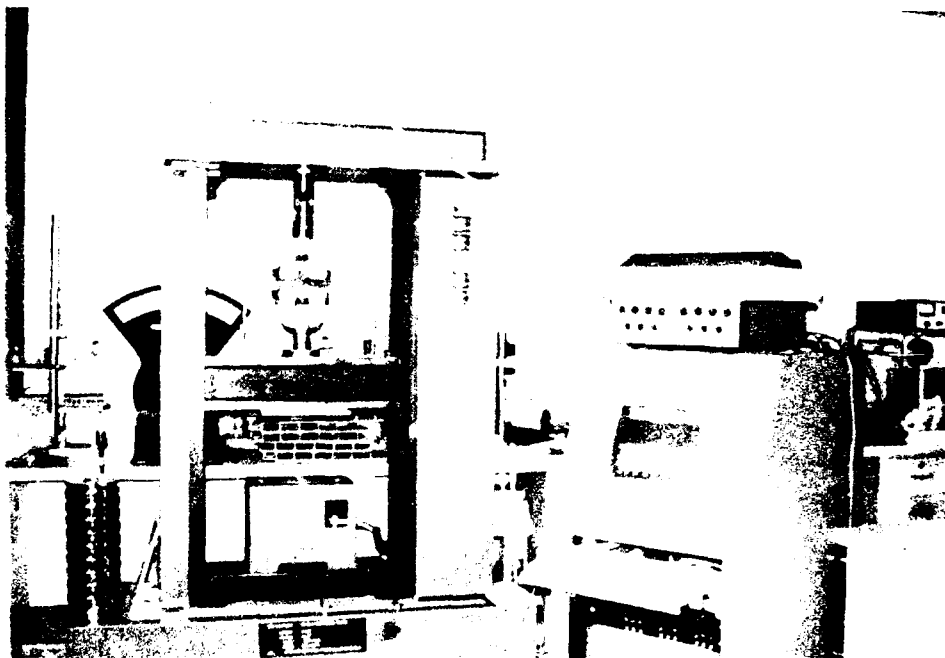


Figure 2. A view of the laboratory setup, showing the mechanical component and the control panel.



Figure 43. Flute T-Peel Strength Test.

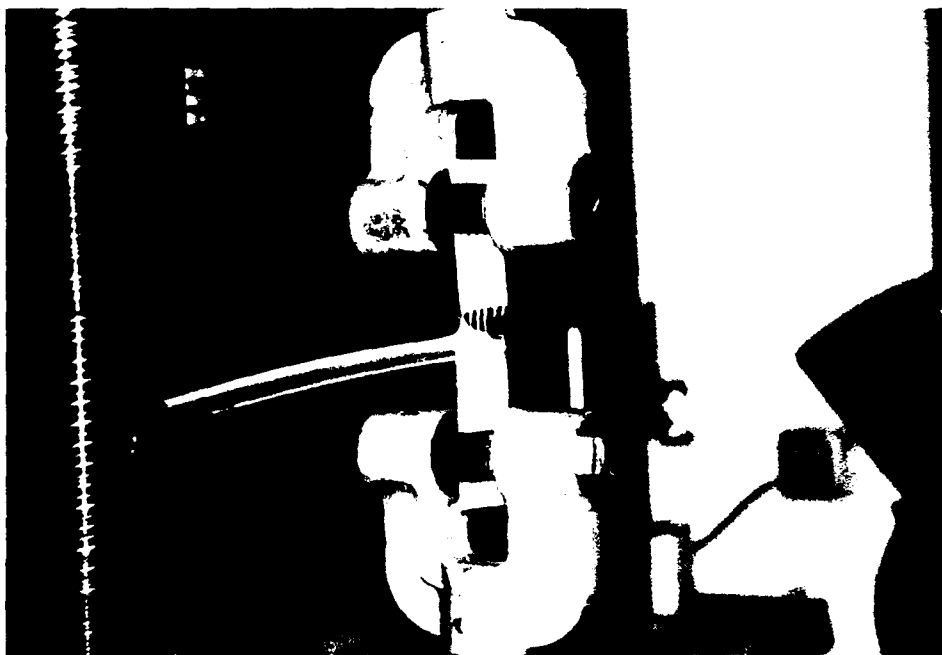


Figure 44. Co B Material Rupturing During the Flute T-Peel Strength Test.

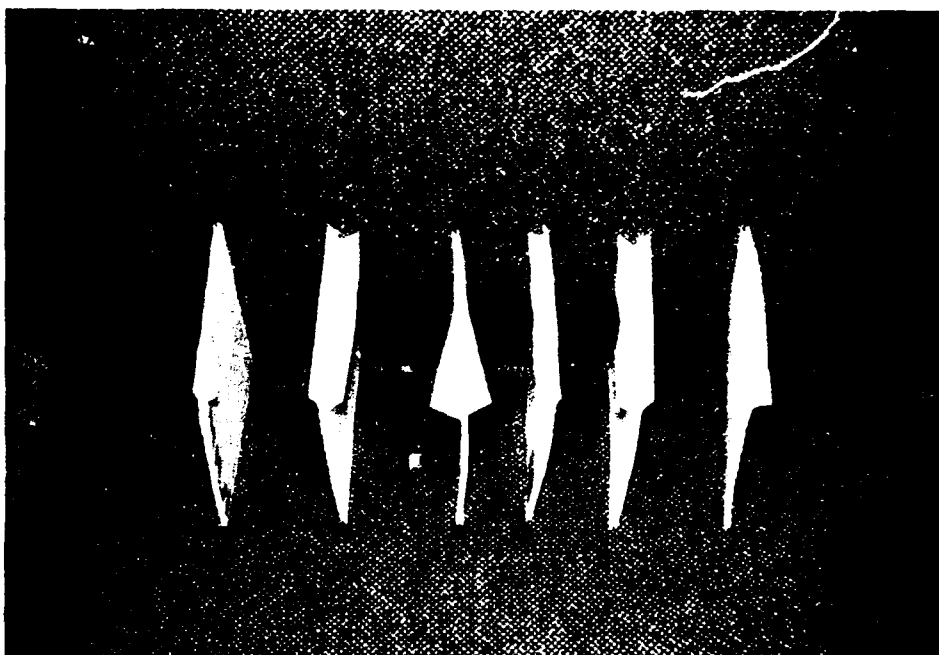


Figure 45. Co A, Material 1, Delamination which Occurred after the Humidity Test.

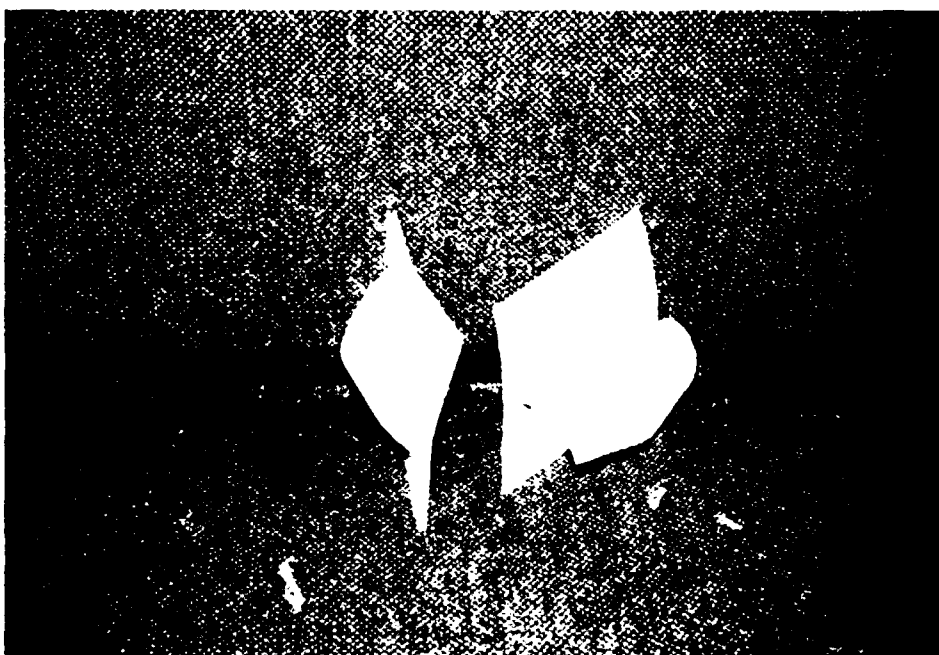


Figure 46. Co A, Material 1, Sample Delaminated by Mechanically Pulling the Layers Apart.

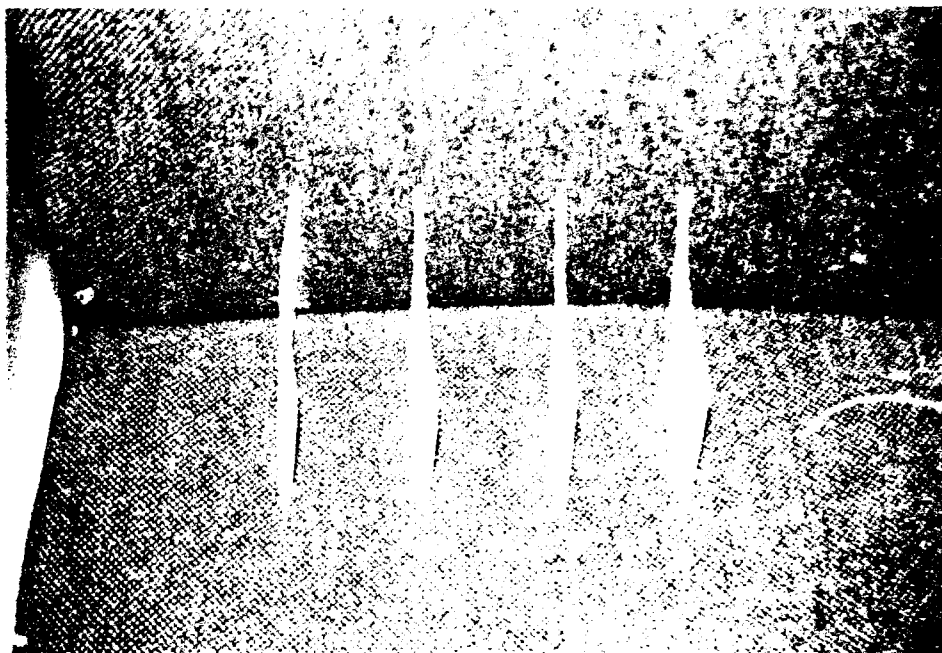


FIGURE 17. A. Material after the Barium Dye.

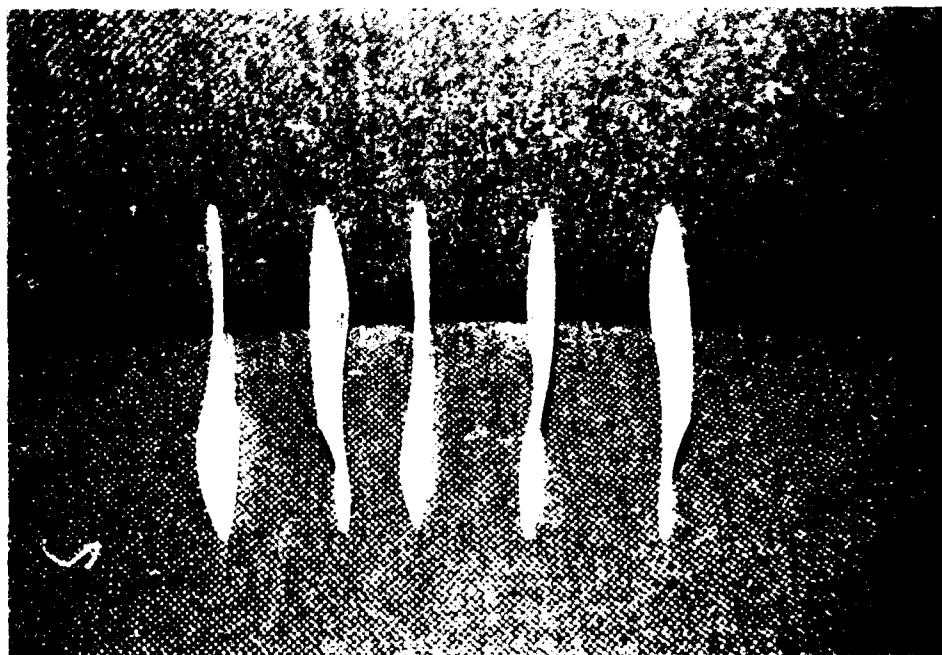


FIGURE 18. Material after the Barium Dye.

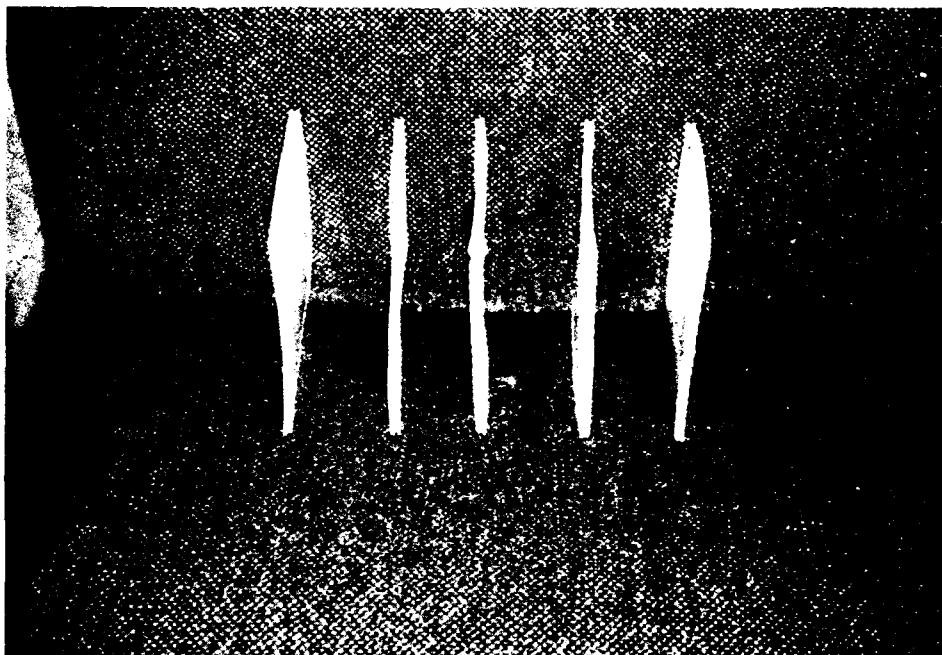


Figure 49. Company C Material after the Humidity Test.

APPENDIX C  
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APPENDIX D  
REPORT DOCUMENTATION

# REPORT DOCUMENTATION PAGE

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OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified			1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY None			3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release distribution unlimited	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE				
4. PERFORMING ORGANIZATION REPORT NUMBER(S) Air Force Packaging Evaluation Activity 93-R-05			5. MONITORING ORGANIZATION REPORT NUMBER(S)	
6a. NAME OF PERFORMING ORGANIZATION Air Force Packaging Evaluation Activity		6b. OFFICE SYMBOL (If applicable) HQ AFMC/LGTP		7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) HQ AFMC/LGTP 5215 Thurlow St Wright-Patterson AFB OH 45433-5540			7b. ADDRESS (City, State, and ZIP Code)	
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8c. ADDRESS (City, State, and ZIP Code)			10. SOURCE OF FUNDING NUMBERS	
			PROGRAM ELEMENT NO.	PROJECT NO.
			TASK NO.	WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification)  Evaluation of Mail Trays				
12. PERSONAL AUTHOR(S) Susan J. Misra				
13a. TYPE OF REPORT Final		13b. TIME COVERED FROM JUL 92 TO JUN 93		14. DATE OF REPORT (Year, Month, Day)
				15. PAGE COUNT 59
16. SUPPLEMENTARY NOTATION				
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB-GROUP		
			Mail Trays, Mail Tray Material, Plastic Corrugated Container, Plastic Corrugated Material, Mail, Container	
19. ABSTRACT (Continue on reverse if necessary and identify by block number)				
<p>The Air Force Packaging Evaluation Activity (AFPEA), in response to a request from the United States Postal Service Engineering and Development Center (USPS EDC), conducted container testing and materials testing on mail trays and their plastic corrugated material, from three manufacturers. The trays were tested against FED-STD-101, Methods 5007.1 and 5019.1 and FED-STD-648A, Paragraph 5.8.3. The material was tested against MIL-P-83668A and MIL-STD-810E, Method 507.3. The mail trays were provided by the USPS EDC. The mail tray material was provided by the manufacturers.</p> <p>The test series was performed at the Air Force Packaging Evaluation Activity, 5215 Thurlow St, Wright-Patterson AFB, Ohio, 45433-5540.</p> <p>SUMMARY</p> <p>An evaluation was done on the performance of the mail trays and their material.</p>				
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